REPORT RESUMES

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A COMPARISON OF TWO METHODS OF TEACHING CONCEPTS ABOUT THE PLASTICS INDUSTRY FOR INDUSTRIAL ARTS EDUCATION. FINAL REPORT.

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THE OBJECTIVES OF THE STUDY WERE TO COMPARE EDUCATIONAL TOYS AND THREE-DIMENSIONAL NONPRODUCING MOCKUPS WITH COMMERCIAL PLASTICS PROCESSING EQUIPMENT FOR RELATIVE EFFECTIVENESS OF TEACHING PLASTIC CONCEPTS, AND TO COMPARE THE RELATIVE EFFECTIVENESS OF THESE TWO METHODS IN DEVELOPING MANUAL DEXTERITY. TREATMENT A (EDUCATIONAL TOYS AND MOCKUPS) WAS GIVEN TO 77 BOYS AND TREATMENT B (COMMERCIAL EQUIPMENT) WAS GIVEN TO 74 BOYS FROM TWO JUNIOR HIGH SCHOOLS. STUDENTS IN BOTH GROUPS WERE DIVIDED INTO THREE ABILITY LEVELS ON THE BASIS OF THEIR SCORES ON THE IOWA TEST OF BASIC SKILLS. EACH TREATMENT CONSISTED OF 4 HOURS DEVOTED TO GENERAL TOPICS, 4 HOURS OF DEMONSTRATIONS, AND 12 HOURS OF STUDY AND PRACTICE ON THE EQUIPMENT. A 116-ITEM TEST DEVELOPED TO EVALUATE PLASTICS KNOWLEDGE, COMPREHENSION, AND APPLICATION WAS ADMINISTERED THREE TIMES TO DETERMINE PRIOR LEARNING, INITIAL LEARNING, AND RETENTION. SOME OF THE CONCLUSIONS WERE--(1) PRIOR KNOWLEDGE OF PLASTICS WAS NOT SIGNIFICANTLY DIFFERENT BETWEEN THE GROUPS RECEIVING DIFFERENT TREATMENTS, (2) THERE WAS NO SIGNIFICANT DIFFERENCE IN DEVELOPING MANUAL DEXTERITY BETWEEN TREATMENTS OR AMONG ABILITY LEVELS, (3) RETENTION OF PLASTICS KNOWLEDGE WAS SIGNIFICANTLY DIFFERENT BETWEEN TREATMENTS IN FAVOR OF COMMERCIAL EQUIPMENT, AND (4) ON THE BASIS OF PRETEST AND POSTTEST SCORES THERE WAS A SIGNIFICANT INCREASE OF PLASTICS KNOWLEDGE EXCEPT FOR THE LOW ABILITY GROUP IN ONE SCHOOL IN TREATMENT A. THE TOTAL PROGRAM SEEMED EFFECTIVE, AND THE PLASTICS TEST SEEMED SUFFICIENTLY SENSITIVE TO MEASURE INITIAL LEARNING AND RETENTION. THE ITEMS IN THE TEST EVALUATION PROCEDURE, INCLUDING THE ORIGINAL TEST ITEMS, THE REVISED TEST, A SUGGESTED EQUIPMENT LIST, A SAMPLE COURSE OUTLINE AND UNIT, SPECIAL REPORTS ON THE PLASTICS PROGRAM, REFERENCES, AND LETTERS OF EVALUATION ARE INCLUDED. (EM)

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CHAPTER I

THE PROBLEM

Introduction

Recently the plastics industry has become important to our national economy. Plastics are also becoming an important part of many contemporary industrial arts programs. However, until recently the development of plastics courses has been slow. This development has been hampered by a lack of suitable equipment with which to teach the concepts of the industry. This lack of equipment has led to the use of substitutes with which these concepts were taught.

Because of this shortage and because funds for the purchase of what many consider suitable plastics equipment are not always readily available, it seemed appropriate to evaluate the relative effectiveness of substitute equipment such as educational toys, models, mock-ups and instructor built equipment. Therefore, this investigator proposed comparing the relative effectiveness of two of these substitutes, educational toys and non-producing mock-ups, in teaching plastics concepts with that of commercially built plastics processing equipment, recognizing that other comparisons could also be made.

Since the problem of teaching concepts with any type of equipment is a part of education in general, consideration is given first to these relationships.

Education

When one speaks of education one speaks of a process which gives rise to many problems, some of which are readily solvable and some which require great effort to resolve.

Webster's New Collegiate Dictionary (1953) describes education as a process for developing or cultivating the organism mentally and morally. In the process, the organism, in this case the human being, gathers information, knowledge or skills through some type of experience, either formally (in school or college) or informally (out of school).

Formal education, the concern of this investigator, involves that process of education in which the learning experiences are directed by a teacher. An educator, then directs the formal learning experiences of his students regardless of their age. Formal education constitutes a system of instruction directed by educators which provides students with the experiences which are deemed necessary by those who are charged with the educational responsibility.

The experiences which the students are exposed to in formal education are designed, rather generally, to help the students develop concepts concerning the many and varied subjects or disciplines resident in the system. Often problems develop as to what represents the best method or the best equipment to develop certain concepts through formal education.

This study was an attempt to solve one problem of concept formation in industrial arts which involves the selection of appropriate equipment as aids to effective learning. In order to understand this problem better, one must first understand some of the terminology. Brief explanations of the terms and their definitions and connotations are included at this point to facilitate the process of explanation.

Industrial Arts

The industrial arts curriculum teaches students selected concepts which are derived from the industrial segment of our society; it does this primarily through the use of tools, machines and materials as instructional devices.

The Industrial Arts Policy and Planning Committee (IAPPC) of the American Vocational Association has defined industrial arts as ". . . the study of our technology, including industrial tools, materials, processes, products, occupations and related problems" (American Vocational Association, p. 3).

Similar definitions have been advanced in official bulletins by the American Council of Industrial Arts Supervisors (ACIAS), a division of the American Industrial Arts Association (1963, p. 3-6) and the staff of the Bureau of Industrial Arts Education of the State of New York (1960, p. 11). The former also suggested that industrial arts forms an integral part of general education and the latter added that this subject should reflect current industrial and technological trends.

Content of Industrial Arts. Traditionally industrial arts has been divided into several sub-areas which are generally derived from the major materials or processes of industry. The sub-areas vary somewhat in different geographical areas of the United States.

In this study the investigator recognized seven selected material or process oriented sub-areas which currently seem to be the most universally taught at the secondary level. These are automotive or power mechanics, drafting,electricity-electronics, graphic arts, metalworking, plastics and woodworking.

Several seemingly valid reasons for changing the structure of industrial arts as advanced recently were recognized, but none of these new structures has enjoyed widespread use or acceptance to date. Therefore, the present study has limited the selection of content areas to those which are most widely accepted, although the results of this study may fit well into some of the newly proposed structures.

Nine sub-areas of the field have been listed by the IAPPC in a late issue of Industrial Arts Education (American Vocational Association, p. 4), as "ceramics, drafting, electricity-electronics, graphic arts, metalworking, plastics, power mechanics, textiles and woodworking." The ACIAS list included all the above except ceramics and textiles while the Bureau of Industrial Arts Education for the State of New York included ceramics and textiles. Schmitt and Pelley (1966), in Industrial Arts Education, found sixteen categories of industrial arts courses, some of which were overlapping.

The tools, materials and machines which are utilized in industrial arts to teach the concepts of industry are used physically by the students to produce products or articles. These projects are the means or vehicles employed to teach the industrial concepts.

In an article entitled Industrial Arts Education, William J. Micheels (pages 1 and 2) wrote that

> Working with tools and materials has always been a part of the educational process -- even long before schools were invented . . . . The distinctive features of the industrial arts shop are the tools, materials and machines.

The association of the hand, the tool and the mind has long been accepted as one underlying concept of industrial arts. John Dewey, with whom "learning by doing"has been associated, and early educators like Pestalozzi, Fellenberg and Herbart, advocated the concept of working with tools and materials to learn their use and relationship to life. In industrial arts this association should result in the learning of concepts involving tools, machines and materials. A more complete treatment of the historical aspects of this subject has been included in Chapter II.

Concepts

Concepts, according to Face and others in Approaches and Procedures in Industrial Arts (Wall, 1965, p. 65), ". . . are the materials and tools of thought processes." As used in this study, they are the commonly identifiable understandings about a process, a material or a tool and their relationship to each other as they are used in industry. To understand the term "concept" better, this investigator turned to the explanations offered by several psychologists and educators.

In a paper entitled "The Concept of the Concept," found in Categories of Human Learning edited by Arthur W. Melton (1964, p. 226), Kendler described a concept as:

> A complicated phenomenon . . . . As a first approximation, concepts have three conceptual properties; they are associations, they function as cues (stimuli), and they are responses.

Archer (Melton, 1964, p. 233), in his comments on Professor Kendler's paper, believed there was a fourth property of concepts. He believed that "words" subsume the other three properties and of them he wrote, ". . . these words are associations, they are cues and they are responses." Further Archer stated that "Concepts are not just words -- they are meaningful words used as class labels -- and the acquisition of the meaning is surely a continuous and variable process."

Gagne (1965, p. 58), in The Conditions of Learning summarized concept learning when he wrote that "The learner acquires a capability of making a common response to a class of stimuli that may differ from each other widely in physical appearance. He is able to make a response that identifies an entire class of objects or events."

Face and others have defined a concept as ". . . a psychological construct resulting from a variety of experiences . . . fixed by a word or idea, and having functional value to the individual in his thinking and behaviour" and that concepts ". . . may be grasped at all levels of understanding from concrete to abstract; from vague to clear; from inexact to definite."

Concepts in Industrial Arts. The concepts of industry have been taught under a material or process oriented structure for a number of years as was indicated earlier in this chapter. Several different structures for teaching industrial arts concepts have been proposed. Two of these, because of their reference to concept attainment in industrial arts, are briefly reviewed here.

Face and others have advanced the American Industry or Conceptual Approach to teaching industrial arts. They have proposed presenting the common concepts of industry as a substitute framework or, as Bruner (1963) called it, a structure. They include essentially the same types of material now presented under the traditional process oriented structure and some materials which are not.

Another proposed approach to industrial arts has been suggested by Lux, Ray and Towers of Ohio State University and Stern of the University of Illinois (1966). These investigators have promoted the praxiological structure for the conceptual development of industrial arts and they have labeled their project "The Industrial Arts Curriculum Project." Their framework, which has been based on the structure of technology, recognizes and limits the study of industry to three dimensions: industrial management practices, industrial production practices and industrial material goods.

Both the Stout American Industry and the Ohio State Industrial Arts Curriculum programs for teaching the concepts of industry were initially designed to be conducted in existing or modified industrial arts shops. The final form that shops for these approaches take is yet to be determined. The present investigator believes that regardless of which of these structures is used to present industrial concepts, many of them may be transferred from one material area to another or may have similar applications in other situations. More importantly, however, the major emphasis on concept attainment characterizes each structure.

Adhesion, for example, may be used in many situations which require the bonding together of two materials. In discussing the learning of this or any concept, Face and others were quick to point out that ". . . it is necessary to take an active part in the process . . ." of concept formation and that "Basic to concept formation is the role played by the senses in perceiving objects, events and attributes."

Many examples of concepts which have been taught in industrial arts can be found. Each concept relates to one or more of the sub-areas of industry forming the structure of the industrial arts program. Students may learn the concept of plastics molding, a method of forming plastic materials. Students may also learn a specific type of plastic molding called compression molding. This concept has been defined by The Society of the Plastics Industry, Inc. (1966, p. 34) as, ". . . the squeezing of a material into a desired shape by application of heat and pressure to the material in a mold." Compression molding has been called a concept because this process has been done with materials, molds and processing equipment which differed widely in properties and appearance, but represents a common class of objects or events. Heat and pressure on a molding material in a closed mold are the commonalities required.

Concepts Taught with Equipment. Industrial arts uses tools, materials and equipment in addition to forms of communication such as words, drawings and pictures to teach concepts. These are taught with the use of equipment which present those concepts of industry associated with similar industrial equipment.

A hand operated laboratory type compression molder provides an example of the type of equipment which may be used for teaching the compression molding concept. Such compression molders closely resemble industrial production equipment except for their size and hydraulic system. A hand operated hydraulic system may be substituted for the power driven system.

Realism

In order to effectively teach the industrial concepts involved the items used to teach them should be realistic, have a high degree of realism, be anchored in reality or be as real as possible. These items should have the above qualities without undue cost to the school or not be so highly automated as to cause confusion.

The Random House Dictionary of the English Language (Stein, 1966) defined real as being ". . . genuine, not artificial, counterfeit or imagination . . . being an actual thing; having objective existence; not imaginary." It also defined reality as a ". . . state or quality of being real . . . a real thing or fact . . . something that is real" and realism as ". . . interest in or concern for the actual or real, as distinguished from the abstract . . . the tendency to view or represent things as they really are."

Realism in Industrial Arts. Contemporary industrial arts teaches students concepts which are derived from the industrial segment of our society. Students learn these concepts by working with the real tools, machines and materials of industry, by working with realistic, not artificial, things or with ideas alone. They work with real woods, metals, plastics and machines to build or construct real projects, instead of participating in artificial exercises.

Items of equipment used to teach the concepts of industry have varying degrees of realism, however. Some items of equipment resemble the real thing in industry more than other items; hence, the items of equipment may have varying degrees of realism.

Realism in Equipment. For the purposes of this study a realistic piece of equipment labels one which accurately presents the industrial concept and accurately resembles in appearance and operation the industrial production equipment of that concept. Realism in equipment specifies how well the equipment meets that requirement. The degree of realism, then, means the degree to which the equipment accurately presents the industrial concept and accurately resembles the appearance and operation of the industrial production equipment.

The most realistic equipment, by this definition, would be the actual industrial production machines with which the industrial concept was concerned. That equipment which presents the same concept and resembles the appearance and operation of, but which was designed for other than industrial production, would be rated less realistic than the industrial production equipment. The industrial production equipment then, would be the "real thing".

Realistic industrial arts equipment was characterized as that equipment which accurately presents the concept and resembles in appearance and operation the industrial production equipment, but which had been designed for industrial arts or some non-production use. At the same time, it was not a toy. Generally, it would be less realistic than industrial production equipment.

Two criteria for the selection of realistic industrial arts equipment seem obvious: (1) the equipment must accurately present the industrial concept and (2) the equipment must accurately resemble the industrial production equipment in appearance and operation. The degree to which the equipment satisfies these criteria determines the degree of realism satisfied.

Selection of the proper equipment to satisfy these criteria and to teach the concepts in the most effective manner without undue cost to the school, has always been a problem which this investigator felt needed investigation. In order to determine which equipment was most effective, a comparison between the use of equipment of different degrees of realism was proposed by the writer.

Before examining this proposal further, a review of the problem of equipment selection for the school seems appropriate.

Equipment Selection

General Problem

School districts of all sizes and types are constantly faced with the problem of buying capital equipment as new equipment has to be purchased and old equipment replaced. New types of equipment are becoming available at an ever increasing rate and new course offerings often require these new types. Guides for the selection of such equipment, more often than not, are lacking. The responsbility for the selection of capital equipment falls on the personnel of the school district. Recommendations by the teacher involved are usually sought by school administrators. When consulted, however, the teacher may not have a clear conception of which equipment would be best for the situation. The teacher may turn to published equipment guides if they are available. Often these are written in general terms or are entirely lacking.

The Problem in Industrial Arts

The problem of equipment selection has always been acute in industrial arts, a major user of expensive capital equipment. Shops and laboratories must be equipped initially and additional equipment added regularly in order to provide students with safe, well maintained and up-to-date facilities.

Schmitt and Pelley (1966) found that the annual national average expenditure for capital industrial arts equipment per school in 1962-63 was $1,063. Schools which enrolled between 500 and 749 students spent a little over $1,200 while schools of over 2,500 students spent over $2,500 for equipment per year. A total expenditure for equipment for the 1962-63 school year in the United States was reported to have exceeded twenty million dollars.

Equipment for teaching the concepts of industry have been classified by this writer into four broad general categories: (Type 1) heavy duty industrial production equipment with automatic controls or feeds, (Type 2) medium or light duty single purpose industrial or laboratory equipment or heavy duty single purpose home shop equipment with or without automatic feeds which closely resemble the equipment used in industry and which present the industrial concept of the similar heavy duty industrial production equipment, (Type 3) small, light duty multipurpose home shop equipment, and (Type 4) improvised equipment, educational toys and non-producing three dimensional mock-ups and models which present the industrial processes or concepts.

A precedent seems to have been established by industrial educators who have recommended the use of single purpose operational Type 2 equipment which, although somewhat lighter, closely resembles that used in industry.

Concerning the selection of equipment for use in industrial arts shops, Scherer, in the 1959 edition of the ACIATE Yearbook, _Planning Industrial Arts Facilities_ (Nair, Ed., 1959), wrote that:

> Any method or procedure in teaching can be efficiently carried on if machines are of standard design, small or medium in size, and typical of the type used in some area in local industry . . . . Selection of equipment should reflect objectives in the development of attitudes and applications of basic knowledge under varying conditions . . . . It is essential that the equipment be capable of producing fine quality work (p. 67).

Gordon O. Wilber (1954), in Industrial Arts in General Education, Chapter XVIII, "School Shop Equipment," stated that

> The type, amount, and characteristics of equipment in a school shop will have a significant effect on the program which can be developed. If the equipment is adequate and well suited to the requirements of the teacher and students, meeting the objectives of the course will be greatly facilitated. If, on the other hand, the equipment is inadequate or of a type not suited to the needs of the program, the achievement of desired purposes becomes difficult -- if not impossible . . . . Machine tools should be purchased on the basis of the purpose for which they are to be used. For example, a unit shop may require heavy production type machines, whereas a general shop will probably require only a machine of medium or even light weight . . . . Some important factors to be considered in the choice of machine tool equipment have been developed under the leadership of Elroy W. Bollinger. The group recommendations are as follows:
>
> "Each tool, each machine, each bench and each piece of apparatus must provide for a maximum of pupil participation in its use . . . . In addition to this, each item of equipment must represent a basic industrial process." . . . Buy tools which fit the students. This does not mean to purchase toys.

Roy W. Roberts (1965, p. 444) advised industrial arts educators to purchase machines

> designed for a single purpose or type of work rather than multipurpose machines . . . . Equipment designed for industrial arts rather than heavy, production type equipment should be installed in the industrial arts general shop. The machines should be equipped with either ball or roller bearings and should have sufficient capacity to handle the work of the shop.

The capital equipment described in the above three statements by these leaders generally specified Type 2 equipment for the general shop and Type 1 equipment for the unit shop. Both were more costly than the lighter, Type 4 equipment which may have also required more repairs and upkeep and caused more down-time in the shop.

Industrial educators might well argue that the investment in educational toys, non-producing three dimensional mock-ups and models for school use would be poor because of their short life, the increased probability of repairs due to the design of the toys for more limited use, the replacement costs, and the generally slower rate of production of usable parts from the educational toys. Additional factors may be cited as reasons for not purchasing Type 4 equipment. The time lost from down-time may be costly in terms of educational value to the student. The additional time required of the instructor to build non-producing mock-ups and models might better be spent preparing other course and lesson materials. Also, duplication of educational toys would be necessary in order to allow each student sufficient time to operate each type of equipment due to the slower production rate of the toys. These factors may, in themselves, justify the purchase of more costly Type 2 equipment. However, consideration should also be given to the relative effectiveness of the equipment in the teaching of concepts.

The investigator felt that the Type 4 equipment had a lower degree of realism than Type 2 equipment for teaching industrial concepts. Type 4 equipment resembled Type 1 equipment less than Type 2 equipment because, in addition to a great difference in physical appearance, the Type 4 equipment was more simplified and in some cases oversimplified. In the writer's experience, the educational toys did not give a true impression of the concept of industry to the student. Production of parts on educational toys was much slower and much less accurate or dependable than on Type 2 equipment. Students often become discouraged when using some of the educational toys due to the lack of speed, accuracy and dependability.

Three dimensional non-producing mock-ups and models resembled Type 1 production equipment even less than educational toys. The mock-ups were often an abstract representation of a machine or process which did not allow the student first hand productive manipulation and "feel" of the equipment in operation. The student often had to imagine what was happening as the mock-up was explained and it only showed "how" the process or concept worked.

Type 2 equipment, in the investigator's experience, provided the student with a different impression of industrial production, its speed, accuracy, economy, and production of interchangeable parts than educational toys and mock-ups.

On the other hand four reasons may be enumerated for utilizing educational toys and non-producing mock-ups in industrial arts. The first concerns simplicity of design and operation as opposed to realism in equipment. Another involves the teaching of concepts rather than specific techniques. The third concerns teaching the relationships within the concepts (Gestalt theory) instead of the association of identical elements (Association theory). A fourth reason might be the lower cost of the educational toys and non-producing mock-ups.

In some cases the process or concept being dealt with may be so complicated, difficult to observe or inaccessible for study through the normal direct experiences that simplified substitutes such as educational toys and mock-ups might provide a more effective means of presenting them. "Such substitutes for confusing or unmanageable or inaccessible first-hand experiences are easier to study than the originals that they represent", according to Dale (1954, p. 46). Because of their simplicity, educational toys or three dimensional mock-ups may be more effective than commercial equipment which, although more realistic, may tend to be more complicated and restrict the process from view. The elimination of extraneous stimuli in the toys and mock-ups might provide an increased focus on the operating principles.

Another possible justification for educational toys and mock-ups might be that more emphasis would be placed on the concept involved rather than the technique of operation. Since they are simplified versions of the commercial equipment, the toys are designed for simple operation with easy-to-follow directions. Such ease of operation developed for the young person might allow greater emphasis on the concept than the technique or product. Because mock-ups often require little or no manipulation, instructional emphasis might also be centered around the concept. The operation of commercial equipment, however, might demand a higher degree of concentration on the operating technique resulting in neglect of the concept.

A third possible justification for toys and mock-ups involves whole ideas rather than specific elements within them. This general Field or Gestalt theory of learning involves the relationships between the various elements of a concept or the "acquisition of cognitive structures" (Kingsley and Garry, p. 89). Under it students concentrate on the whole concept rather than individual elements of the concept as it relates to equipment. Thus, the type of equipment utilized would be immaterial. Because this theory deals with the universal elements within the concept and their relationships rather than specific details relating to equipment, it allows for changing equipment over time without the necessity for retraining. Proponents of the Gestalt theory, such as Bruner (1963, p. 25), claim that a greater degree of transfer of knowledge may result from its application. The association or Thorndikian "Connectionism" viewpoint, which is in contrast to the Gestalt theory, concerns itself with the learning of the elements within the concept or the "acquisition of habits" (Kingsley and Garry, p. 89). It assumes that mastery of these elements will lead to an understanding of the whole concept, as Kingsley and Garry pointed out. According to them, "This conception of learning involves the point of view that wholes are developed by compounding parts. Learning is a process of putting together units to form total experiences and complex forms of behavior." Here an understanding of the present equipment becomes emphasized. The elements of the concepts are associated directly with the elements of the equipment.

The cost factor may also become a valid reason for installing educational toys and building non-producing mock-ups. The Mattel Vac-U-Form toy costs $12.00 while the lowest priced commercial vacuum former with a vacuum source listed at $160.00. A greater price differential exists between the Kenner Injection Molder toy ($10.00) and the lowest priced commercial injection molder ($300.00). Mock-ups are inexpensive to build, but time consuming.

Certain educational administrators and the general public have opposed the purchase of more costly and specialized Type 2 equipment for some phases of industrial arts. Theyhave argued that the same educational goals could have been realized regardless of the type of equipment used.

Problem in Plastics

Plastics, one of the newer subject areas, has had little organization and course planning prior to about 1960. Before that time, few if any industrial arts courses or units in plastics at the high school and college levels, reflected the major processes of the plastics industry. Most of the plastics operations being taught in industrial arts were cutting, shaping, filing, sanding, drilling, cementing and finishing of acrylic plastic sheet.

Three studies (Cantor, 1952; Golomb, 1962; and Runnalls, 1966) have shown rather conclusively that this has been true. Runnalls found that college industrial arts departments have only recently begun to teach industrial plastics process concepts actively.

Consequently, little thought has been given prior to about 1960 to the establishment of precedents for the purchase of capital equipment for teaching plastics in the secondary schools or colleges.

Equipment has not been generally available for teaching plastics courses or units until very recently and suitable equipment for use in the schools has not yet become available for teaching some plastics concepts.

A study of the concepts of the plastics industry, methods of teaching these concepts and the equipment available for use in schools to teach them was made by the Bureau of Industrial

Arts, Department of Education, The University of the State of New York, Albany, during the summer of 1964 at the State University College, Oswego, New York. This investigator was a member of the ten man team which conducted the study.

The result of this study was the recent publication of An Experimental Resource Unit in Plastics for Industrial Arts (1966) to be used in the secondary schools. This resource unit includes lesson plans for teaching each of the industrial plastics concepts and has a suggested capital equipment list. This study was checked for accuracy and technical content by members of the plastics industry as listed in the Resource Unit.

The American Industrial Arts Association has undertaken a project to develop a Guide for Equipping Industrial Arts Education Facilities (1967). This investigator also participated in the preparation of the plastics equipment section of that document.

A survey by the writer showed that equipment for teaching most of the plastics concepts was available in three of the previously mentioned categories. Industrial production equipment (Type 1) was available for all the processes of the plastics industry. Reasonably priced medium or light duty industrial or laboratory equipment (Type 2) was available for most plastics concepts. Exceptions to this were rotational molders, reinforced plastics spray-up equipment, thermofusion equipment, vacuum metalizers and vinyl dispersion molding equipment. Multipurpose home shop type equipment (Type 3) was not available for plastics processes. Educational toys (Type 4) were available for thermoforming, injection molding, vinyl dispersion molding and extrusion. However, mock-ups and models (Type 4) were nonexistant and needed to be constructed by the instructor as required.

Concern of the Study

Based on the concern of educators who want to have the correct equipment without excessive cost to teach the concepts in question, the investigator felt that a study should be conducted which compared the relative effectiveness of equipment for industrial arts which exhibited two different degrees of realism.

This writer was also concerned with whether the degree of realism represented by the educational toys and non-producing mock-ups and models (Type 4) was significantly different than the degree of realism represented by the commercially available operative plastics processing equipment (Type 2) in teaching a beginning plastics course.

This study was designed to determine if the concepts of the plastics processing industry could be more effectively taught to junior high school students in a beginning plastics course by using the commercially designed and produced operative plastics processing equipment or by using educational toys and non-producing three dimensional mock-ups, such as an instructor might make. The eighth grade level was selected because a minimum of prior learning of industrial concepts would be expected while the students would be familiar with industrial arts shop procedures. The eighth grade also provided the most convenient schedule for inclusion of such a unit in the schools involved.

Both types of equipment were chosen to provide a vehicle for teaching the concepts of the plastics industry. The commercial equipment (Type 2) was chosen to represent the higher degree of realism as it more closely resembled the industrial production equipment (Type 1).

The difference in the development of manual dexterity through the use of each of the types of plastics equipment was also studied to determine if students developed more manual dexterity from the use of one type than from the other.

Objectives

General Questions

This study was designed to answer two questions.

1. Is there a significant difference in the relative effectiveness of teaching plastics concepts with educational toys and three dimensional non-producing mock-ups (Treatment A) and teaching plastics concepts with commercially designed and produced plastics processing equipment (Treatment B)?
2. Is there a significant difference in the relative effectiveness of these two types of plastics equipment in developing manual dexterity in the students?

The main variable was the degree of realism presented by each of the two types of plastics equipment and its effect on concept attainment and on manual dexterity. Secondary variables were the effects of the different types of equipment on three levels of student ability within each of the groups when separated into high, middle and low ability groups.

Specific Hypotheses

In order to determine the relative effectiveness of the two types of equipment the following specific hypotheses were advanced concerning this study.

1. For the prior learning of concepts measure (a pretest administered one day prior to the treatment), there is no difference:
    a. between the means of the treatment populations
    b. Among the means of the three ability level populations
    c. in the patterns of ability means within the two treatment populations (interaction).
2. For the initial learning of concepts measure (a posttest administered one day after the treatment), there is no difference:
    a. between the means of the treatment populations
    b. among the means of the three ability level populations
    c. in the patterns of ability means within the two treatment populations (interaction).
3. For the retention of plastics concepts measure (a retention test administered two weeks after the treatment), there is no difference:

a. between the means of the treatment populations

b. among the means of the three ability level populations

c. in the patterns of ability means within the two treatment populations (interaction).

4. For the two manual dexterity measures, placing and turning, (manual dexterity tests administered as pretests one day before the treatment and post-tests one day following the treatment), there is no difference:

a. between the means of the treatment population

b. among the means of the three ability level populations

c. in the patterns of ability means within the two treatment populations (interaction).

5. For the prior learning and initial learning of concepts measures, there is no difference between the means at each ability level for each treatment.

6. For each pair of criterion measures within each treatment at each school, there is no linear relationship between the measures.

Transfer of knowledge items were to be included in the test shich was used as a pretest, post-test and retention test for plastics concepts. The content of each of these tests was to reflect the transfer of knowledge as well as the understanding and retention of knowledge about plastics.

Each of the criterion measures were to be analyzed separately for each school.

Limitations

Two general limitations were placed on this study to keep it manageable.

Specific Manipulative Skills

Specific manipulative skills were not important at the eighth grade level so were not considered. It was recognized that the students were not presumed to develop specific manipulative skills because of the exploratory nature of this level of industrial arts study. Specific manipulative skills would not transfer to industrial types of equipment upon graduation because of the long period of time between eighth grade and high school graduation, the skills required in industry could well change in that span of time and skills need constant practice to be maintained over a period of years. Manual dexterity, however, was considered important and was taken into account.

Other Industrial Arts Outcomes

There are other industrial arts outcomes or objectives which one treatment might satisfy, such as health and safety, prevocational experience and interest in industry, but which the other treatment might not. These, however, were not considered as a part of this study.

Definition of Terms

A number of terms need specific definition for the purposes of this study. The following, which have not been previously defined, are explained specifically for this study.

Introductory First Course in Plastics

The introductory first course in plastics was designed to introduce the study of plastics to students in the junior high school who had no previous courses or units in this area. The course was offered at the eighth grade level for twenty clock hours with appropriate content selected from *An Experimental Resource Unit in Plastics for Industrial Arts*.

Industrial Production Equipment

Industrial production equipment (Type 1) includes equipment which usually comes large, heavy and primarily designed for automated, mass production of plastics parts in industry.

Operational Commercial Plastics Equipment

Operational commercial plastics equipment or commercial plastics equipment refers to that equipment (Type 2) which has been commercially designed and manufactured for light, non-automated, commercial production, for laboratory use or for industrial arts use. This equipment has the capacity for limited, small scale, non-automated mass production of plastics parts, yet economical in cost for school purchase. The machines are easy and economical to operate and capable of demonstrating effectively the concept under study. This equipment actually uses plastics raw materials common to the concept.

Educational Toys

Educational toys (Type 4) are those toys which are operative and designed to present a plastics concept. Some of the toys process actual plastics materials common to the concept while others do not. They do, however, process some type of material similar to the material common to the concept. They may illustrate only part of a concept.

Non-Producing Three Dimensional Mock-ups

Non-producing three dimensional mock-ups (Type 4) refers to three dimensional visual aid devices which are instructor built specifically to illustrate the plastics concept, but which do not actually produce sample parts from the materials common to the concept. Some have moving parts while others do not.

Two Dimensional Teaching Aids

Two dimensional teaching aids include films, filmstrips, wall charts, blackboard diagrams, pictures, diagrams and drawings from books, magazines and brochures and other similar items.

Overview of the Study

Subjects

Sixty-one eighth grade industrial arts students (boys) from Susan B. Anthony Junior High School, Minneapolis, Minnesota and one hundred-two eighth grade students (boys) from Como Park Junior High School, St. Paul, Minnesota, for whom Iowa Test of Basic Skills Grade Equivalent Scores, Eighth Grade, Form 1 were available, were used during the 1965-66 school year.

Procedure

One half of each school group was subjected to Treatment A, Educational Toys and Three Dimensional Non-Producing Mock-Ups and the other half of each school group was subjected to Treatment B, Commercial Plastics Equipment. Each group was divided by level of ability according to the Iowa Test of Basic Skills (ITBS) grade equivalent scores into three sub-groups which were high, middle and low ability levels.

Test measures were taken on prior learning, initial learning, retention and manual dexterity.

Analysis

Analysis was by two-way analysis of variance to determine the significance, if any, in the differences in means of the plastics test scores attained by Treatments A and B for prior learning, initial learning and retention at the three ability levels. The differences in means for the manual dexterity tests were analyzed by two-way analysis of variance and covariance techniques. Probability levels of .05 and .01 were calculated. In each case where analysis of variance or covariance or correlational techniques were used in this study, the five percent level of significance has been used for the rejection of the null hypothesis.

Summary

A number of topics in the field of education and the discipline of industrial arts education have been introduced and defined in Chapter I, some of which have been sufficiently developed while others require further consideration for broader understanding. Chapter II has been written to report the review of the literature concerning concept formation in education as well as equipment selection criteria and plastics instruction in industrial arts.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The literature reviewed in this chapter has been grouped into four categories: studies concerned with the attainment of concepts, the historical development of realism in industrial arts, studies and books concerned with equipment and equipment selection in industrial arts and other disciplines and studies, and articles and books concerned with the development of plastics instructional programs in schools and colleges. This review has included books, journals, periodicals, and Master's and Doctoral theses.

The areas of review have been limited to research or writings that are relevant to this study. Less pertinent research and writings were excluded by delimitation of this review to the four categories mentioned above.

Concepts

Concept formation involves a complicated process which does not seem to be completely understood by many of the best minds who have studied it. A number of experiments on the subject have been recorded in the literature, some of which are concerned only with a minute detail of the concept formation process. Several experiments which seemed very general in nature, yet relevant to the problem of this study are reviewed here.

An early experiment which seemed to have set the stage for later works in this field was conducted by Smoke (1932) in 1931. He discarded the earlier "common elements" approach to concept formation and advanced a theory of concept formation as, ". . . a response to relationships common to two or more stimulus patterns." His definition of concept formation, ". . . the process whereby an organism develops a symbolic response (usually, but not necessarily, linguistic) which is made to the members of a class of stimulus patterns but not to other stimuli," seemed to be compatible with more recent definitions as stated in Chapter I.

Smoke's experiment involved systematic viewing of two-inch square cards containing drawings of concepts which were assigned nonsense syllable names. Confusion drawings of the concepts which violated, ". . . at least one of the conditions essential to the concept in question" were randomly interspersed among the concept drawings during some of the experiments. The correct concept drawings differed greatly, but still truly represented the concept. The subject viewed the cards, which changed at a uniform rate, until he felt he knew the concept. The time spent acquiring the concept was considered a measure of the difficulty of the concept and speed of learning. The subject was then tested on what he conceived the concept to be by three methods; by a completion test, by drawing the concept, by picking out the correct and incorrect concepts on a sixteen item identification test. A series of four variations of the experiment were conducted following these same general guidelines. Positive and negative instances were used together and separately as variations of the basic study.

Some of the conclusions arrived at by Smoke were that (a) some individuals cannot give accurate verbal formulations of the concepts learned, (b) some subjects learn from negative instances while others do not, (c) speed of concept formation is not affected by the variation in the number of negative conditions imposed, (d) "The process of concept formation appears to involve grouping." (e) insight seems present at times, (f) concept formation involves hypothesis testing, (g) wide individual differences in concept formation were found and (h) rapidity of concept formation is probably correlated positively with the ability to make a high intelligence test score.

Heidbreder (1945, 1946, 1946b, 1947) investigated concept attainment in a manner similar to Smoke except that three types of concepts were identified and employed; concrete objects such as face, building and tree, spatial forms such as 0, OC, and # and numerical quantities such as 2, 5 and 6. She defined a concept as ". . . a logical construct which, through signs or symbols or both, is transferable from situation to situation and communicable from person to person."

Heidbreder used three examples of each of the three types of concepts, as shown above, on the Spindler-Hayer exposure apparatus. Each variation of the nine individual concepts had nonsense syllables assigned to them as names. The hypotheses she presented were, "That in human beings, . . . the perception of concrete objects is the dominant mode of cognitive reaction . . . " and "That the attainment of concepts may be treated as an extension and refinement of the mode of reaction involved in the perception of concrete objects." She further wrote that, "According to this hypothesis, human beings, in attaining and using concepts, are performing a function closely analogous to the one they perform in perceiving concrete objects.

The assumption was made by Heidbreder (1946b), ". . . that cognitive reactions can be arranged in an order of dominance which is determined by their function in the guidance and control of behaviour." She conducted three experiments, all of which supported her hypothesis that the three types of concepts were attained, ". . . in a regular order: concepts of concrete objects first, concepts of spatial forms next, and concepts of numbers last." The difference in speed of learning the three types was statistically significant. "The indicated order," according to Heidbreder, ". . . is from concrete to abstract and everyone knows that concepts become increasingly difficult to attain as they become more and more abstract."

Her definition of a concrete object was, ". . . a material body in the external world, typically visable, tangible, and manipulable." Spatial forms included any shape which could be represented in at least two dimensions and which was essentially a nonsense figure. A number was described as a direct expression of a quantity.

Other researchers have performed similar experiments since the original ones conducted by Heidbreder. According to Wenzel and Flurry in The Order of Concept Attainment (1948), Overstreet detected that concepts were attained in the following order, concepts of objects first, spatial concepts second and color concepts in no particular order. They also stated that Bensley found that concepts of concrete objects were formed first, color concepts second and number concepts last and that Ivy reported the same order of concept attainment as Bensley.

Wenzel and Flurry then reported that, "The results (of their experiment) revealed the same general tendency as other similar experiments in regard to the sequence of attainment of the three types of concepts tested." They added that, "Concepts of concrete objects were attained first, spatial forms next, and numbers last, forming three clearcut categories."

In all, sixteen experiments were performed which tended to confirm this hypothesis. Only one was conducted by Dattman and Israel (1951), which rejected the hypothesis of the order of attainment. In the opinion of this researcher it did so because the subjects were confused by irrelevant factors which were introduced into the study.

Several experiments have been conducted which were concerned with concrete and abstract concepts. These, however, did not attempt to place them in order of attainment as did the later Heidbreder experiments and those that followed her pattern. W. Edgar Vinacke (1951) summed up a number of them in his article, "The Investigation of Concept Formation", which appeared in the Psychological Bulletin. Of these experiments, he wrote, "Weigel found that individuals characteristically displayed contrasting concrete and 'categorical' (or more conceptual) approaches." Vinacke described Bolles as further analyzing, ". . . these approaches, suggesting that concrete performance is primarily determined by sensory impressions whereas the more conceptual or abstract performance is a response to objects as representative of a class or category." He described Hanfmann and Kasanin (Vinacke, 1951) as having, ". . . developed a standardized procedure for testing conceptual performance with the Vigotsky sorting test." Vinacke stated that they ". . . have distinguished three levels of performance, namely, a primitive, 'concrete' performance, an intermediate performance showing some aspects of conceptual thinking but not others, and an advanced conceptual performance."

Hanfmann, who made a preliminary report on the Vigotsky test, according to Vinacke, described ". . . the 'perceptual' (concrete) approach", as one in which "the individual keeps in close touch with the material and gets his ideas from looking at or handling the blocks (the blocks used in his tests)." Hanfmann's description of the "thinking" or conceptual (abstract) approach was one in which ". . . the subject develops hypotheses without paying much attention to the blocks, which are utilized to check the hypotheses; all of this may be accomplished without actually touching the blocks," according to the account given by Vinacke.

He concluded his discussion of concrete and abstract concept research by relating the Goldstein and Scheerer card sorting experiments, of which he wrote, "They define the concrete attitude as realistic -- that is, dependent upon immediate sensory impressions -- whereas the abstract attitude is characterized by detachment from immediate reality and includes more than the 'real' stimulus."

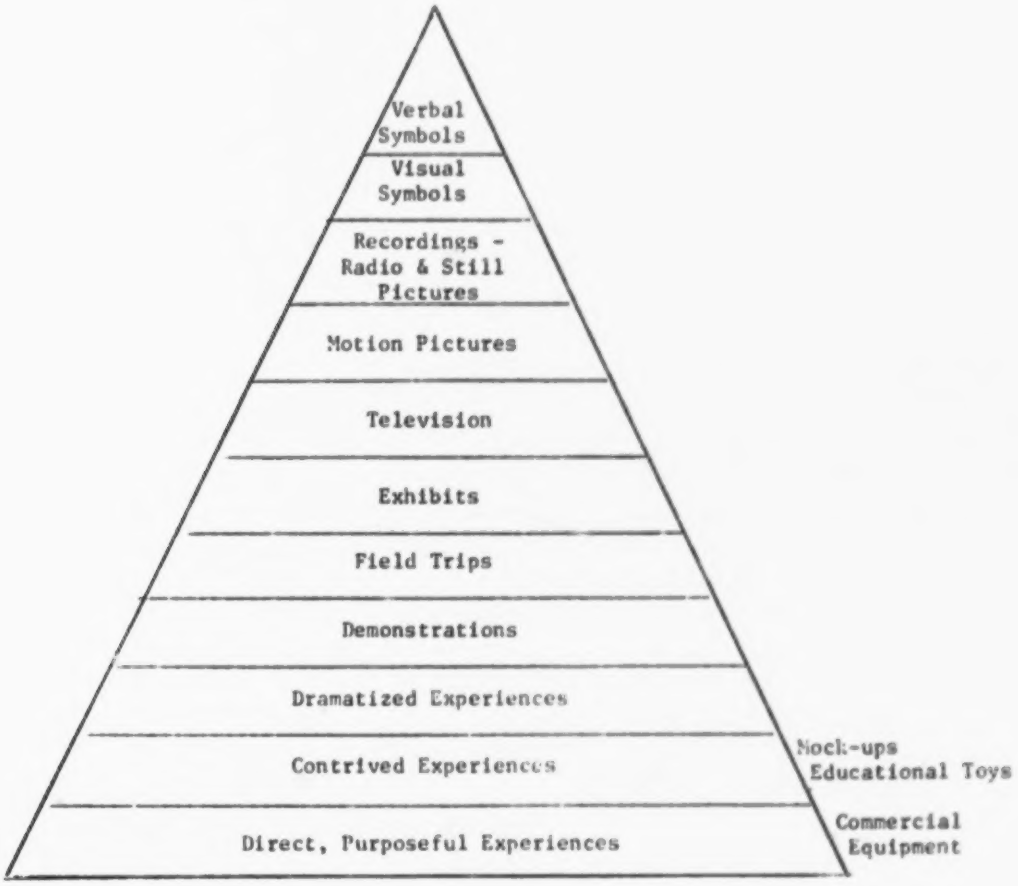
Edgar Dale (1954), in his book, Audio-Visual Methods in Teaching based much of the logic of the methods he advocated on concepts, of which he stated that, "Education involves the making of suitable classifications of our experiences -- that is, the building of concepts." He called these classifications of experiences "words", as did Archer (1964) in his comments on Kendler's paper. Dale wrote that they can be of "real-life learning" or "the bookish, unreal, abstract substitutes for real life situations." To explain his classification of the different types of experiences according to their relative degree of abstractness or concreteness he presented his continuum of ". . . the process of making experiences usable . . ." in the form of a cone -- "A Cone of Experience." This cone of experience was best described in his own words when he wrote, "The broad base is 'direct experience'; the pinnacle is the kind of experience that is as far removed as possible from direct contact with objects." Figure 1 shows a reproduction of Dale's cone of experience which seemed to be a direct extension of the Heidbreder theory of the order of concept attainment. Dale stated that "When a concrete object is involved there is little difficulty. But when we attach a name to an idea, a concept, an abstraction, the problem becomes complicated." This appeared to agree with Heidbreder's theory.

As Dale described it, "The base of the cone represents direct reality itself as we experience it firsthand." He suggested that the "direct, purposeful experiences" are concrete experiences. "If you move upward from the base," according to Dale, "you move in the order of decreasing directness." He equated the pinnacle of his cone with abstractness or abstract experiences. Thus, one moves from the concrete (direct, purposeful) experiences at the base to abstract (verbal, symbol) experiences at the top.

The direct, purposeful experiences were further described by Dale as, ". . . the bedrock of all education . . . something you can get your hands on, . . . direct participation, with responsibility for the outcome."

Figure 1

Dale's Cone of Experience


Verbal Symbols
Visual Symbols
Recordings - Radio & Still Pictures
Motion Pictures
Television
Exhibits
Field Trips
Demonstrations
Dramatized Experiences
Contrived Experiences
Direct, Purposeful Experiences
Mock-ups
Educational Toys
Commercial Equipment

Contrived experiences, the second step on the cone, have been defined as being more abstract experiences which are substitutes for unmanageable or inaccessible firsthand experiences. They differ from the original or direct, purposeful experiences in size and complexity or both. In some situations these imitation situations may be better for teaching purposes than the real thing. Contrived experiences may be easier to understand due to their size or complexity, a condition which was also reported by Miller and others (1957).

At the pinnacle of the cone are verbal symbols which, ". . . may be a word for a concretion (horse), an idea (beauty),

. . . a philosophic aphorism (honesty is the best policy), or any other representation of experience that has been classified in some verbal symbolism."

He did not list the direct, purposeful experiences of industrial arts, but stated that most of the concept learning in this field falls in this category. Therefore, it has been assumed that most tools, machines and materials used in industrial arts contribute to direct, purposeful experiences, the base division of his cone.

Models and mock-ups, and he classifies all small toys as models, should be used only when the real thing or real experience cannot be brought into the classroom or when students may be able to understand the concept better through the use of the model or toy because of its lesser complexity. He called models, mock-ups, objects and specimens "contrived experiences," the second step on his cone.

The use of commercial plastics equipment (Type 2), the investigator believed, falls within the lower band of Dale's cone (direct, purposeful experiences) and the educational toys and three dimensional mock-ups (Type 4) into the second band of the cone (contrived experiences). This has been graphically illustrated in Figure 1 on page 40.

Dale further explained that, ". . . we can move to the abstraction only through the concrete." If this is correct, his direct, purposeful experiences are direct contact with concrete objects and if concepts of concrete objects are learned before spatial forms and numbers as Heidbreder and others concluded, then the use of the most concrete or realistic examples of equipment from industry, which are not overly complicated nor unduly large in size, might be the most effective media for teaching concepts involving industrial equipment and processes.

"Increasing abstractness", in Dale's words, "does not mean increasing difficulty," but as Heidbreder concluded, less abstract concepts are learned first. The plea, then, would be to present concepts in the most concrete manner with the most concrete or least abstract equipment. To state it another way, the concepts should be presented by the most realistic method for more efficient learning. This implied that the more realistic commercial equipemnt (Type 2) should be used to effect this increased efficiency.

Bjorkquist (1965), who applied Dale's cone of experience to his experiment in teaching orthographic drawing, stated that, "Dale encouraged teachers to make learning experiences more meaningful and realistic for students by moving them away from the abstract and toward the concrete." He concluded that orthographic projection problems presented with more concrete teaching aids (scale models) was a more efficient method of teaching orthographic drawing than those presented without these aids.

John Dewey once wrote, "Now, all principles by themselves are abstract. They become concrete only in the consequences which result from their application" (Dewey, 1939). Regarding learning through experience, Curti (1950, Encyclopedia of Educational Research) wrote:

> We greatly need a more realistic and humanistic kind of education which will determinedly avoid more verbal teaching and seek to equip our children with serviceable growing ideas, thoughtfully acquired out of their experience.

In his book, Dale (1954) frequently quoted Dewey and his views on realism in education.

Realism in Industrial Arts

Historically, the development of industrial arts seemed to foster the development of a more realistic method of education which made the use of tools, materials, processes and machines a basis for this new method of teaching. A brief review of this history of education and industrial arts reveal repeated references to the use of tools, materials and processes. When analyzed, these references tend to show a trend toward a more realistic approach to teaching. Industrial arts, then, grew out of efforts to make learning more realistic to better meet the needs of the students.

Early Philosophy

A number of early educational leaders and philosophers advocated methods which were practical application approaches to education. Working with things while they were studied rather than just studying them became a method which suggested a more realistic approach to study -- more realistic because the students worked with the real thing rather than just studying it. This early broad practical approach to education was at first an attempt to help those students whom, today, we might call disadvantaged youth. Later this method became more widely used.

Charles A. Bennett (1926), in writing about John Henry Pestalozzi who has been called, "The Father of Manual Training," wrote:

> He believed that children in school should learn to work, not only because of the economic value of skill and the habit of labor, but because his experience gave sense-impressions which, like the study of objects, become the basis of knowledge. He recognized the fact that "doing leads to knowing.

Pestalozzi developed, promoted and experimented with ideas introduced by Rousseau. Later Philip Fellenberg organized them into practical administrative schemes. Fellenberg's farm and trade school followed, in general, the method of Pestalozzi.

Heinrick Heusinger (Bennett, 1926), according to Bennett, ". . . made manual work the central point of his system." Herbart (Bennett, 1926), who became acquainted with Pestalozzi according to Bennett, wrote, "Every growing boy and youth should learn to handle the recognized tools of a carpenter, as well as the ruler and compass . . . ."

Fredrick Froebel (Bennett, 1926) later developed these basic ideas into his kindergarten concept where handwork occupied a high place of distinction.

These early educators and philosophers used manual work as a method of teaching. This method, which might be called handwork or manual work, brought students closer to the real world of work and allowed them to learn by doing. However, it did not systematically organize the tasks into sequential learnings. Instead the students worked in gardens, built necessary things for the situation at hand and learned to use the tools associated with the required task. In most cases they were also taught the rudiments of the subjects considered basic to the life of the day.

Organization of Instruction

The early attempts at teaching through manual work were mostly unorganized, unsystematized and reflected the seasonal work around the school or farm. Later, educators realized that some organization was necessary for teaching through manual work in order that the students would learn all the tools of the trade and be more able to support themselves in later life instead of only becoming familiar with the tools and processes through casual contact. These educators also felt that this learning should take place in a sequential manner from simple to complex.

Thus, the division of manual instruction by operations, tools and finally shops which represented the trades taught came into being. This resulted in a higher degree of realism than previous attempts because the students learned a trade rather than just isolated jobs, and learning was aimed at a closer relationship to the life work of the student. In short, the learning was supposed to be more useful to the student.

In 1868, Victor Della Vos and his associates (Bennett, 1937) devised the Russian System of Shop Instruction which featured separate shops for joinery, woodturning, blacksmithing and locksmithing. This departure from the prevailing method of manual work, was organized along the lines of the trades of the day. The students learned trades instead of just how to use tools. Models were used as a basis of instruction and were arranged in an order of increasing difficulty. Each pupil was provided with a bench and a complete set of tools with extra tools for common use on a board in the shop.

The early Sloyd Schools of Scandinavia developed out of the home industries of those countries to promote the learning of the arts and trades of the time. In 1872, Otto Salomon came to Naas, Sweden to join August Abrahamson in an industrial school. The Swedish school was established around such trades as carpentry, carving, turning, smith's work, basket making, saddlery, stone cutting, fret work and painting.

Salomon recognized the importance of tools suited to the purposes of the instruction and he questioned the use of small tools found in "children's tool boxes"; in his opinion these tools were inferior to those which he suggested (Salomon, 1894). Salomon felt that tools smaller in size (he called them slighter) than those generally used by adults in sloyd carpentry should be used by the students, but the tools should be as substantial and durable as those used by their elders. Salomon's students used the smallest sized standard tools available and he advised people that children stood the same chance of getting hurt on "toy tools" as on the ordinary saw, axe, and knife.

Salomon suggested the use of the most realistic tools possible, except that they should be adapted to the children by using an appropriate size. He seemed to imply in his writings that students learned more readily and more realistically with adult type tools, a statement which showed his concern for realism. Salomon also utilized exercises and models in his instruction.

Integration with other Subjects

Up to this point in history no great concern seemed evident that manual instruction should be related to or integrated with other educational disciplines except in an incidental manner. Educators commenced to be more concerned about the total education of the student. Attempts to relate and integrate manual and mental disciplines began to appear. This seemed to be more realistic than former approaches to education because subjects such as reading and mathematics were important to the conduct of a trade as well as in the manual skills.

Educational leaders in Germany recognized, during the latter part of the 19th Century, that manual instruction was a part of general education and advocated integration of manual instruction with the other subjects. They felt that manual instruction could not be separated from the training of the mind.

The Manual Training Movement of Germany, which received its first impulse from Denmark and Sweden, emphasized three ideas, social, economic and pedagogic. Freidrick Buderman (Bennett, 1937) was quoted as having written, "Practical and physical work is a demand of human nature." Dr. Waldemar Goetz (Bennett, 1937) claimed general educational value for instructional handwork in his paper entitled "The Completion of the Instruction of the School by Means of Practical Activity." Manual instruction became an integral part of the scheme of general education in Germany and combined individual with class-type instruction.

Introduction of Manual Instruction into America

Organized manual instruction was introduced into the United States by Della Vos through the Centennial Exposition at Philadelphia in 1876 (Bennett, 1937). Although Professor Calvin Woodword of Washington University, St. Louis, used shop work to set the theory for his mathematics classes through model building before the exposition, it was not until he saw the Russian Exhibit there that he began to develop a system of shopwork placed on the same plane as other school subjects. Dr. Woodword gave shopwork as important a place in his new school scheme as mathematics and science. He sought to teach the essential mechanical principles of all the recognized trades and their relationship to other fields. Of his efforts he stated, "Put the whole boy in school."

Woodword's Manual Training School at Washington University soon became one of the models for secondary schools in the United States. Dr. John Runkle (Bennett, 1937), President of Massachusetts Institute of Technology, also saw the implications of the Russian Exhibit and soon developed manual instruction at his institution. He established the School of Mechanic Arts in conjunction with MIT to teach the mechanic arts needed by young engineers and to provide, ". . . manual education for those who wish to enter upon industrial pursuits rather than to become scientific engineers." Runkle's school covered two years' work and included arithmetic, algebra, geometry, English, physics and drawing in addition to shopwork.

The relationship of studies in these new schools to the needs of the students after graduation brought a more realistic approach to education through a recognition of the needs of youth.

John Dewey's Philosophy

Dr. John Dewey based many of his thoughts, experiments and writings on some of the literature reviewed here. Dewey's was a philosophy of realistic approaches to the education of youth which set the pace for his "New Education" at the beginning of the Twentieth Century. He looked to real life as the basis for the child's education. Dewey selected occupations that were real in school life for his teaching. Concerning this real life selection, he wrote, "Mere activity does not constitute experience" (Dewey, 1963, p. 161-2):

> It can hardly be said that many students consciously think of the subject matter as unreal; but it assuredly does not possess for them the kind of reality which the subject matter of their vital experiences possesses . . . . . Where schools are equipped with laboratories, shops, and gardens, where dramatizations, plays, and games are freely used, opportunities exist for reproducing situations of life, and for acquiring and applying information and ideas in the carrying forward of progressive experiences.

According to Bennett (1937), Dewey spoke before the National Education Association in 1901 and declared:

> The problem of the elementary school today is, I conceive, to make the life in the school more real; more an epitome of the kind of thinking, feeling, and doing that obtains in real life; more a reflection of the actual life outside the school walls . . . .

While Dewey did not specify the degree of realism for equipment to be used in the school, it seemed evident after reviewing some of his works, that he would have specified the highest degree possible consistent with the ability of the school to provide it.

Industrial Arts

Manual instruction in the United States developed during the first half of the 20th Century into what is now known as industrial arts. Under the influence of such men as John Dewey, Charles Richards and Fredrick Bonser, this instruction emerged into the "project method" of teaching the use of tools, materials and equipment. This method, which replaced the models and exercises of an earlier era, allowed the student to design, plan and construct a project of his own choice, or in some cases, the instructor's choice. The project method can be described as a further step in the direction of greater realism because the student's project fulfilled his needs, was his own creation and was more useful to him than a model or an exercise.

Recent Approaches

Recently a number of industrial arts educators have advocated new approaches to industrial arts which are aimed at increasing realism in industrial arts from the standpoint that they purport to illustrate the complex of industry to students. Mass production, creative design and various new structures for industrial arts have been proposed.

Maley (1964) advocated developing creative thinking talents of students through experimental shopwork in industrial arts. Prichard (Wall, 1965) and others, including this writer have advocated mass production in industrial arts as a means of teaching a more realistic body of content in industrial arts by stimulating an insight or understanding of industrial production and its place in our society. DeVore (1964) and Olson (1963) have proposed similar reorganizations of industrial arts content along a technological structure representing a more realistic study of industry. Lux, Ray, Towers and Stern (1966) have developed a "Praxiological" structure for industrial arts which has been reviewed briefly in Chapter I.

The American Industry approach, another reorganization of industrial arts content being developed at Stout State University and as reviewed in Chapter I, has two main objectives.

1. To develop an understanding of those concepts which apply directly to industry.
2. To develop the ability to solve problems related to industry.

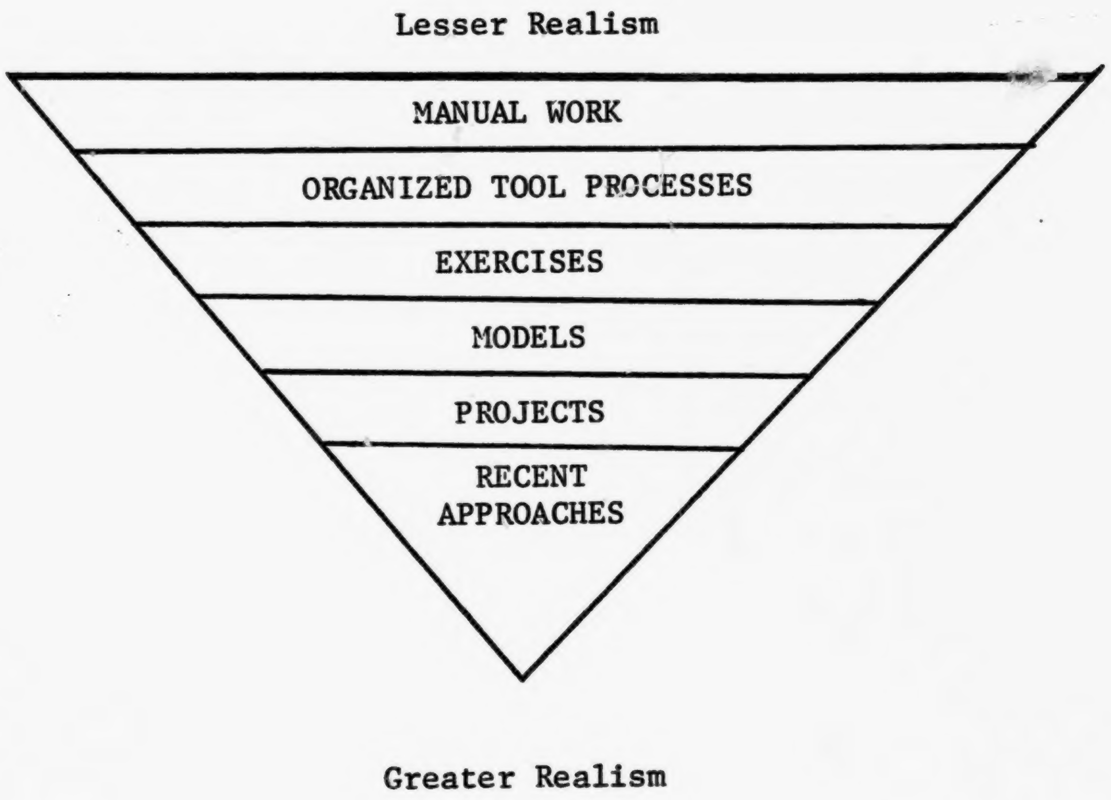
The structure for the American Industry program has been attributed to Bruner and Burton, Kimball and Wing (Wall, 1965). The direct relationship of these programs to industry seemed to be a way in which to study our American industrial complex adding greater realism to industrial arts.

Summary

Realism in manual instruction, which evolved into industrial arts, seemed to have gradually increased over the years reflecting changes both in education and industry. The broad manual work approach of the early 19th Century gave way to organized manual instruction. This in turn was replaced by a philosophy which recognized both the need for organization in manual instruction and for integration with other educational disciplines. Later the project method was employed in conjunction with an organized manual instruction entitled industrial arts. Recent proposals have suggested that a higher degree of realism should be sought through closer association of industrial arts with industry. The exact form which this should take has yet to be determined. Figure 2 graphically illustrates how this writer believes this change has taken place.

Figure 2

The Historical Evolution of Manual Instruction
Showing a Trend Toward Increased Realism


Lesser Realism
MANUAL WORK
ORGANIZED TOOL PROCESSES
EXERCISES
MODELS
PROJECTS
RECENT APPROACHES
Greater Realism

Equipment Selection

The use of tools, materials and equipment has been essential to industrial arts and its historical predecessors. Throughout the years it seemed to have been generally accepted by industrial educators that tools, materials and equipment were a vital part of the program as explained previously. The types of equipment used and the relative effectiveness of different types of equipment have not been subjected to research study.

Following a reasonably exhaustive review of the literature of industrial arts, no studies which compared the use of one type of equipment with another under similar conditions in secondary industrial arts were discovered. However, tools appropriate for use in elementary school industrial arts were the subject of three studies.

Several authors have stated their criteria for equipment selection, three of which were reviewed in Chapter I. Appropriate comments regarding equipment selection by Erickson (1946) has been reported here. The three elementary industrial arts tool studies and the equipment selection study sponsored by the American Industrial Arts Association are also reviewed.

Elementary Industrial Arts Tools

The three elementary industrial arts tool studies mentioned were the only studies found which could be termed comparative equipment research in this field. For this reason and to show

how little has been done in this field, they are reviewed here. Bonde (1964) studied the use of hand tools in Grade I of the elementary school and suggested appropriate hand tools for that grade level. Doutt (1965) and Hansen (1964) conducted similar studies of elementary school industrial arts tools, the former in Grades 2, 3, and 4 and the latter in Grades 5 and 6. Both also suggested appropriate tools for the grade levels studied.

Secondary Industrial Arts Equipment

Normally the authors of industrial arts subject content textbooks have not specified the types of equipment to be purchased. These writers do imply their preferences for such equipment through the pictures and illustrations used in their books. While only an assumption, the implication of endorsement does occur; this has not been accepted as a valid criterion for the selection of equipment. Some authors of professional textbooks in industrial arts have given specific selection criteria, several of which have already been cited. One other such presentation follows.

Emanuel E. Erickson (1946) suggested several considerations for equipment selection which have not been previously cited. He admonished instructors to survey their equipment needs, satisfy course objectives when purchasing equipment, investigate the equipment available before buying, insure that the equipment will be generally useful and purchase the equipment for instructional purposes only. The equipment should be reasonably priced, frequently used and fit into available space. He reminded his readers to consider orderly purchase of the equipment, available funds and portable versus stationary machines. He discouraged the purchase of combination or variety machines and used equipment.

A committee of the American Industrial Arts Association (1967), in preparing A Guide for Equipping Industrial Arts Facilities, listed seven purposes of the guide, two of which are applicable to this study and are reported here:

1. To provide a guide to school architects, administrators, planners, and industrial arts supervisors and teachers as they plan new and revise existing facilities.

2. To establish criteria for the evaluation of local facility conditions.

The plastics equipment sub-committee of the above mentioned committee, of which this investigator was a member, set up the following criteria for the selection of plastics equipment to be listed in the AIAA Guide.

1. Versatility: Where industry finds it profitable to purchase special equipment which produces rapidly on a very specific operation, the school has a greater need for a versatile piece of equipment that can be adapted for many aspects of instruction. The equipment should take a variety of kinds and sizes of molds.

2. Size: Small capacity is desirable for school equipment because it is not necessary to make large products to illustrate the process. Cost is a factor here too.
3. Ease of Setting-Up: It is desirable to maximize the "plastics" experience and minimize a lot of complicated, time consuming set-up and mold making.
4. Price: Lower cost equipment was specified.
5. Ease of Observing the Process: Equipment should be designed so that the student can see what is happening.

Relevant Studies in Other Fields of Education

The literature of home economics, audio-visual and business education was reviewed, but revealed little which could be termed equipment studies.

Plastics

Plastics programs and program proposals were numerous in the literature, but few have been put into full scale operation. This may be attributed, in part, to the relative newness and recent importance of this industry. Another factor may be that few instructors are knowledgeable in plastics. Nevertheless, colleges and secondary schools have been slow in implementing plastics programs at a time when information and equipment are becoming available at an increasing rate.

A number of articles which show the importance of the industry and help establish the program were available. Books were generally available on most of the sub-topics suggested for inclusion in most plastics curriculum proposals. The most relevant of these have been reviewed. Several Master's and Doctoral theses have also been written on this subject.

Master's Theses

A number of master's theses are available which are concerned with plastics curriculum and instruction. In order to gather additional information about this subject while developing the course outline for the plastics unit in the present study, the investigator reviewed several theses which were found at Stout State University and one at the University of Minnesota. In general, they all agreed with the writer's views, as expressed in the two articles written and reproduced in Appendix C, and lent additional support to the body of content and methods employed in the plastics unit. Two similar studies which were discovered, but not reviewed -- one conducted at Southwest Texas State Teachers College and the other at North Texas State University -- are also included in this list. Although these studies are not quoted directly or reviewed individually they are relevant to the content of this study and worthy of listing in a separate section of the bibliography. They are somewhat overlapping and would be redundant if reviewed individually.

Doctoral Dissertations

Three rather voluminous doctoral dissertations concerning plastics education or equipment have been written, none of which has made a comparison of the relative effectiveness of the commercial plastics equipment and the substitute equipment for the teaching of concepts. Although these studies have been cited previously, they require further elaboration.

Cantor (1952) studied the importance of plastics in our economy and the methods,materials and processes of the industry. He reviewed the methods of employment of plastics processes by the layman and developed what he called minimal plastics equipment needed by the layman. Cantor listed the following processes which should be taught in the school: compression molding, injection molding, jet molding, laminating, extrusion molding, cold molding, blow molding, casting and miscellaneous forming and drawing processes.

In the summary of his analysis of industrial production equipment Cantor wrote that although most of this equipment was not small, portable, easily storable or economical to purchase, ". . . the teaching-learning potential of this equipment for the layman is high, most equipment can be used to make projects or products which are attractive and appealing . . . ."

Golomb's study (1962) involved the development of A Guide to Plastics in the Industrial Arts Program of the Academic High Schools of New York City. In Part I, he surveyed the plastics industry, the aims of industrial arts and the status of plastics in the academic high schools of New York City. Part II was the presentation of his guide for teaching plastics.

In addition to Cantor's list of plastics processes to be taught, Golomb described compression, injection, and extrusion molding as the most important processes of the industry. He also emphasized the relationship of plastics to the functions of industrial arts education and listed the teaching aids and techniques which could be used.

Runnalls (1965) surveyed the plastics courses offered in college and university industrial arts departments of the United States. He found that only sixty-one of 203 institutions contacted offered specific courses in plastics while seventy-three more offered plastics units as a part of other courses. Those colleges which listed units as a part of other courses were found to have weak offerings.

Runnalls' analysis of the plastics industry listed all of the processes described by Cantor and Golomb and added transfer molding, blow molding, solvent molding, coating, steam molding, foaming-in-place, and thermoforming.

Courses of Study in Plastics

This investigator authored a program for teaching plastics in the secondary schools which was published in the September 1964 issue of Industrial Arts and Vocational Education. A reprint has been included in Appendix C-4. Another article on teaching plastics by this writer entitled "An Introduction to Plastics" appeared in the November 1966 issue of School Shop.

A copy of this article has been reproduced in Appendix C-5.

A Plastics Education Guide (1966) was recently published by the Society of the Plastics Industry, Inc. (SPI) including course outlines which support the plastics outline used in the present study. A booklet entitled The Story of the Plastics Industry (1966) published by the SPI, was also used as a guide in preparation of the above outline.

Anderson supplied this writer with a course of study for seventh grade plastics which he developed at Ellis Junior High School, Austin, Minnesota. Vinyl dispersion molding was one process in Anderson's course not mentioned previously.

James Hatch developed a one year Senior High School Plastics Course. It included most of the plastics processes already mentioned plus pulp molding and the history, development of and chemistry used in the plastics industry. Hatch also stressed mold design and construction.

An Experimental Resource Unit in Plastics for Industrial Arts, referred to earlier, contains outlines for demonstrations and related information lessons in the orientation to the plastics industry. Specific lesson materials for the unit outline in plastics used as the base for the course in this study were drawn from the above publication.

The above Resource Unit included a Seventh Year Outline (Appendix C-2) and a Suggested Equipment List (Appendix C-1). The Seventh Year Outline was one of the bases for developing the original Outline for the Proposed Plastics Unit (Appendix A-2). The pattern of content and time allotments employed were adapted to fit the limitations imposed by the present investigation. The above Suggested Equipment List was consulted during the development of the equipment list utilized in this study.

Rogers (1960) developed a technical school program which included a unit in plastics. The writer reviewed his work several years prior to the present investigation. It contained content similar to that taught by the investigator and used for the present study.

Other Articles

A number of plastics articles have appeared in recent periodicals, several of which are reviewed here.

Shields (1962) described ways in which plastics could be taught in industrial arts. Johnson and Anderson (1961) also discussed methods of teaching plastics at the secondary level. Harska (1960) wrote a descriptive article about the plastics industry which included its history. Sevier (1962) wrote about experimentation with plastics at the junior high school level.

Generally, these articles parallel this writer's views on plastics instruction.

Books on Plastics

This investigator has read and reviewed many books on plastics during the past several years. Most of these books deal with the concepts of the plastics industry and some provide project suggestions. A number of the more recent and up-to-date are contained in the Suggested Basic Reference Library (Appendix C-6) which was included in An Experimental Resource Unit in Plastics for Industrial Arts. Because the author helped develop this list it was adopted for this study. Each of the cooperating schools purchased many of these books for their industrial arts reference libraries since they were utilized by the instructors as additional sources of information throughout the study.

Summary

The theory of concept formation, the theory of realism in industrial arts, the equipment selection criteria for industrial arts and the plastics literature reviewed in this chapter all contributed to the development of this study. The concept formation literature provided information about the basis upon which learning took place. The writings suggesting realism in industrial arts furnished grounds for the variable which allowed the two different treatments to be developed. The equipment selection criteria surveyed suggested methods by which one could determine the proper equipment to purchase and the plastics literature helped to develop the course concent of the study. The principles and information derived from the materials reviewed were applied to the remainder of the investigation.

CHAPTER III

THE DESIGN

Introduction

The general design of the study has been recorded in this chapter. It includes the selection procedures, plan of investigation, development of the test instrument, population and sample, data collection and analysis.

Selection Procedures

Selection of the Schools

This investigator conducted an intensive survey of the Minneapolis-St. Paul and suburban area in order to locate a junior high school or schools in which a plastics course or unit, of the type he proposed, was to be offered. He found that Como Park Junior High School, St. Paul, offered a similar unit in the eighth grade, but did not possess all the necessary equipment. He also discovered that the Minneapolis Board of Education planned to purchase and install several items of plastics processing equipment at the Susan B. Anthony Junior High School and that a plastics unit would be initiated there soon. No other schools located in this area offered or indicated they would offer such a course.

The investigator contacted Mr. Sterling Peterson, Consultant for Industrial Arts, Minneapolis Board of Education and Mr. Claudius Wilken, Supervisor of Industrial Arts, St. Paul Public Schools to determine if arrangements could be made to conduct the study in their respective school systems.

Mr. Sterling Peterson, Mr. Raymond Nord, Director of Vocational Education, Dr. Robert Rainey, Consultant for Educational Research and Mr. Roland DeLapp, Principal of Anthony Junior High School, all of the Minneapolis Board of Education, subsequently approved of the proposed experiment for Susan B. Anthony Junior High. This acceptance was subject to the approval of the instructor, Mr. Robert Means. Final approval for the Minneapolis Board of Education was provided by Dr. Clifford Hooker, then Acting Assistant Superintendent of Schools.

Mr. Claudius Wilken, Mr. Roy Isacksen, Principal of Como Park Junior High School and Dr. Walter Leino, Assistant Director, Division of Tests and Measurements, all of the St. Paul Public Schools, agreed to allow the investigation at the Como Park Junior High School subject to the approval of the plastics instructor, Mr. John Bichner. This approval also specified that the writer would furnish all the necessary equipment not available at Como Park Junior High.

All necessary student records were made available by the respective school systems.

Selection of the Instructors

In addition to the selection of a school or schools in which to conduct the research the writer felt that properly prepared instructors, who had satisfactorily completed a college level plastics course and were vitally interested in developing plastics instruction were needed to teach the proposed unit.

As has been pointed out in Chapter I, few courses in plastics have been offered at the college level in the past. This was also true in Minnesota until recently, when at the insistence of the investigator and several other industrial arts instructors from the Minneapolis-St.Paul and suburban area, the Upper Midwest Chapter of the Society of Plastics Engineers and the Department of Industrial Education offered a plastics course through the Extension Division at the University of Minnesota. This course was taught by a noted plastics authority, Professor Fulton Holtby, Department of Mechanical Engineering, Institute of Technology. The course was offered in 1964, 1965 and 1966 during the winter and covered all the processes, equipment and materials required for the proposed unit to be taught in the present investigation.

This researcher felt that successful completion of the course offered by Professor Holtby should be a prerequisite for the instructors who would teach the unit in the present study.

Among the instructors who completed the course during the 1964 and 1965 sessions were Mr. Robert Means of Anthony Junior High School and Mr. John Bichner of Como Park Junior High School.

Mr. Means and Mr. Bichner were subsequently presented with copies of the project proposal and asked to consider teaching the required unit; each enthusiastically agreed to cooperate and help conduct the study in their respective schools.

Both men were considered by their principals and industrial arts supervisors to be highly qualified to teach such a course. Both had demonstrated their prior interest and current desire to learn more about the teaching of plastics at the junior high school level.

Selection of the Equipment

The investigator first inventoried the plastics equipment available at Anthony and listed all the educational toys that could be purchased for teaching plastics concepts. A list of the equipment available at Como Park and a list of the equipment and non-producing mock-ups needed for each school was then developed.

The formulation of the final equipment list was guided by the equipment list (Appendix C-1) from An Experimental Resource Unit in Plastics for Industrial Arts, the tentative copy of A Guide for Equipping Industrial Arts Education Facilities, consultation with Professor Holtby and the writer's personal experience teaching plastics at the junior high level.

The investigator subsequently spent several months locating and borrowing from manufacturers the necessary plastics equipment for Treatment A at Anthony and Como Park Junior High Schools Equipment was matched so that each school would have the same types or makes of equipment for each process. A list of the borrowed equipment and the sources has been included in Appendix C-7.

Selection of the Educational Toys

Four different educational toys with which plastics concepts could be taught were found. Each of these were usable in teaching plastics concepts for which operational commercial plastics equipment was also available. These were the Mattel Vac-U-Form, the Kenner Electric Mold Master injection molder, the Mattel Thing-Maker and the Play-Doh extruder set.

An operational commercial plastics extruder was too expensive to obtain and required more time and equipment to install than was available so it was decided that the Play-Doh extruder should be used to demonstrate extrusion in both treatments. It was not used for practice.

The Mattel Thing-Maker, a vinyl plastisol casting kit, was not used as Commercial Equipment (Type 2) was not available for this process.

Eight Mattel Vac-U-Form kits were donated by the manufacturer and eight Kenner injection molders were purchased. The plastics processes for which equipment was available in each treatment consisted of compression molding, injection molding, thermoforming, heat sealing and plastics welding.

Development of the Non-Producing Mock-Ups

Non-producing mock-ups for plastics welding, heat sealing and compression molding were needed and designed by the author to be as realistic as possible. The models were constructed by Mr. Laurence Vall, a student teacher, under the direction of Mr. Robert Means at Anthony Junior High School. Photographs of these mock-ups are included in Appendix E-1.

Selection of the Instructional Content

Instructional content for the plastics unit was determined by the operational plastics equipment and educational toys available. In addition to the plastics processing concepts presented by the plastics equipment and the educational toys available it was felt that the content should include an introduction to the plastics industry, its history, growth, importance, organization and future.

Specific objectives for each portion of the content outline were developed from which specific test items for the criterion test instrument were written. An outline of the course of study used and the complete course objectives can be found in Appendix A.

Development of the Test Instrument

Introduction

A criterion test was required to detect the differences, if any, between treatments in prior knowledge, initial learning and retention of plastics concepts. Since no such test existed which could be used for these purposes, a single test containing test items which satisfy the categories knowledge, comprehension and application, according to Bloom's (1956) Taxonomy of Educational Objectives, Handbook 1, Cognitive Domain, was developed to evaluate the above three dimensions. It was designed to be administered three times, one day prior to the treatments (prior learning), one day after the treatments (initial learning) and two weeks after the treatments (retention). This arrangement provided comparable measures of the dimensions tested. The advice and guidance of Dr. William A. Kavanaugh, Department of Industrial Education, University of Minnesota, was used in the process of developing and using this test.

First it was necessary, however, to develop a set of course objectives and an outline of the course of study for the unit to determine specifically what could be tested. The problem of available equipment, already discussed, was a determining factor in the development of the course of study and course objectives. After the equipment was selected and the objectives and outline developed, a complete set of testable specific objectives was written. These are reported in Appendix A-7, left hand column. Test items for each specific objective were then developed and are reported in the center column of Appendix A-7.

These objectives for the plastics course of study were developed consistent with the outline in Appendix A-2, the aid of *An Experimental Resource Unit in Plastics for Industrial Arts*, *Technical Education in Metals and Plastics*, *The Plastics Education Guide*, *Plastics Technology*, and the writer's articles, "Teaching Plastics" (Appendix C-4) and "An Introduction to Plastics" (Appendix C-5).

Development of the Test Items

The broad objectives for the course were refined and expanded in order that the body of the course was outlined in terms of the smallest logical units containing testable content. One-hundred-fifty-nine items were constructed to cover the stated objectives. These were also designed to agree with the way in which the material was presented in the text, *Plastics Technology*. Several test items were developed for many of the specific objectives, especially those dealing with the plastics processes, in order to retain in the final revision at least one each of those which were considered best for each specific objective. About one-third more test items were constructed than were expected to appear in the final criterion test.

The objectives and test items were submitted to Professor Fulton Holtby for evaluation. He evaluated each item in terms of relevance to the course, satisfaction of objectives and for technical accuracy. Minor revisions were made at his suggestion.

The objectives and test items were typed on a test evaluation form, developed in cooperation with Dr. Kavanaugh, which displayed each item directly opposite from the stated objective. This form has been reported in Appendix A-7.

The items were constructed to satisfy the first three categories in Bloom's Taxonomy specifying Level I, Knowledge, Level II, Understanding and Level III, Transfer of Application. These categories were further defined in "The Procedure for Reviewing Test Material" (Appendix A-6). This Procedure sheet was supplied to each member of the panel of experts who evaluated the test. The level that each item satisfied, as judged by the investigator, was typed in a column on the right side of the evaluation form, called LEVEL.

Validation Procedures

A suggested list of sixteen experts on plastics, who were either from the plastics industry or were teachers who had taught plastics, was developed. A letter, a questionnaire and an outline of the unit were sent to each of these people to determine if they would cooperate in establishing content validity for the test. Copies of these papers have been included in Appendixes

A-1, A-2 and A-3. Another objective of the questionnaire was to determine if each respondent subscribed to the same general philosophy about teaching plastics as the investigator.

From the fifteen replies, twelve people were selected on the basis of the above criteria to form the panel of experts. Of the three respondents not selected, one chose to have the co-editor of his book, Professor James Church who had also been asked to validate the test, perform the validation, one did not seem to subscribe to the writer's philosophy of teaching plastics and the last did not have time. The names of the members selected are included in Appendix A-4.

A total of 159, four-element, multiple choice test items with objectives were submitted to each of the experts for evaluation. Each was supplied with an instruction sheet (Procedure for Reviewing Test Material, Appendix A-6) and was asked to (a) judge each item for level, (b) judge the correctness, suitability or offer a revision of each item and (c) state any concepts or objectives which may have been omitted. A one-hundred percent response was received from the panel.

The number of test items was then reduced to 125 by eliminating those items which were seriously questioned or rejected by some of the panel members. Level ratings of the questions retained were adjusted to agree with at least seventy-five percent of the panel members. The items, for which the level was questioned, were further reviewed by Dr. Kavanaugh and appropriate levels were assigned to them.

Pilot Study

On February 1, 1966, arrangements were made with Dr. Robert Swanson, then Dean of Applied Science and Technology, Stout State University, to conduct the pilot study in three sections of a beginning plastics course, Industrial Education 203. The purpose of the pilot study was to perfect the test instrument and finalize the procedures for administration.

The pilot study was conducted on February 10, 1966. The three sections, which totaled 75 students, were under the instruction of Drs. Arnold Piersal and Armond Hofer. Although these were college classes and the present investigation was conducted at the secondary level, this situation afforded the nearest approach obtainable for a pilot study of the instrument. The classes at Stout were the only ones available in this geographical area who had studied most of the material included in the test.

The test was administered to the three sections by the writer. Answers were recorded on the Digitek DS 1120-C answer sheets for ease in scoring and item analysis. Students were given note paper and encouraged to record any irregularities detected or questions about the individual items. They were allowed two hours to complete the test and could leave when they had finished. They were timed to determine just how long the test took.

The pilot study of the test was scored and analyzed by the University of Minnesota Student Counseling Bureau's Digitek system.

An item analysis was conducted which yielded the number of responses to each alternative answer for each item. The top 27 percent and the bottom 27 percent of the papers were withdrawn for additional study. The percent of responses for each item for each group (difficulty index), the correct alternatives for each item and the difference in percent of the correct alternatives between the upper 27 percent and the lower 27 percent groups for each item was determined.

Final Review of the Test Items

The items in the test were reviewed, judged to be acceptable and kept if they satisfied all of the following criteria: (a) they were considered a "good" item by at least 75 percent of the panel members, (b) they received a positive 10 percent or higher difference between the upper and lower groups (high group minus the lower group) of the correct alternatives for each item unless the item was known to test material not presented in the course at Stout and (c) at least 50 percent of the students in the upper 27 percent group answered the item correctly or unless the item was known to test material not presented in the course.

Consideration had to be given to the fact that the students at Stout had not completed the plastics course at the time the test was administered and that the course did not cover the history and growth of the plastics industry as thoroughly as the test. Great reliance was placed upon the judgement of the panel of experts regarding those questions on material not included in the course at Stout.

Where more than one question was written to satisfy a testable objective, that question with the highest ratings, according to the above criteria, was retained. Those items which did not fulfill all the criteria were either revised or discarded. An item was revised if its fault was apparent or suggestions for its revision were given by one or more panel members. Items were discarded if no apparent revision was possible, two or more judges suggested discarding it or an item was available with a higher rating covering the same objective. After carefully reviewing each item, 116 were selected for use. These are included in Appendix B-1.

Reliability

The post-test and the retention test were analyzed by the Student Counseling Bureau's item analysis program number four which computed the Kuder-Richardson formula 20 Reliability Coefficient for each test as specified by Walker and Lev, p. 311. Coefficients of .929 on the 116 item post-test and .930 on the 116 item retention test were calculated.

Plan of Investigation

Plan for the Treatments

The instructors and the investigator agreed to limit the plastics unit to 20 clock hours per treatment exclusive of testing time since schedules at both schools would not allow more time for it. Additional processes could have been introduced into the unit had more time and equipment been available. The processes included, however, were considered to be the most widely used in the industry.

Treatment A and Treatment B consisted of equal amounts of time, although the time was proportioned differently for each treatment. The general subdivision of time within the treatments has been detailed in the following paragraphs and shown in Figure 3, page 80, and Tables 1 and 2 on pages 82 and 83.

General Topics. The topics considered for general discussions covered the history and growth of the plastics industry, the important materials and the important processes. Films, film strips, textbooks, wall charts and overhead projections were used as two dimensional media for presenting this part of the course. These two dimensional items, which were the same for both schools, were considered as constants for both treatments; the same films, film strips and textbook assignments were used with equal time allotments for each treatment.

A standard textbook, Plastics Technology (1966), by Robert Swanson was selected for use. It was the only book of its type usable for eighth graders which contained all of the plastics processes necessary for the study. Sixty copies were loaned by McKnight and McKnight Publishing Company, Bloomington, Illinois for the experiment.

A filmstrip with a recorded script, Introduction to Plastics (Trachtman, 1965), prepared by Kitco, Inc., Wichita, Kansas, was borrowed for the experiment. Another filmstrip with a printed script, Talking Plastics, and a film, Plastics Products and Processes, were also used.

Demonstrations. Demonstrations of the equipment took approximately equal time for each treatment. These consisted of visual demonstrations of the equipment, toys or mock-ups at hand.

Non-Producing Mock-Ups. Explanation of the concepts not taught through the use of the educational toys in Treatment A was accomplished by using non-producing mock-ups. After the explanation, the subjects viewed the mock-ups and studied work done by their commercial counterparts of them in lieu of working with the commercial equipment. Time taken for the study of the mock-ups was a part of the practice time as specified in Figure 3.

Practice Time. The practice time consisted of the practical application time, a basic element of industrial arts. It was that residual time remaining in Treatment A which was allotted to the subjects for using the educational toys to produce examples of the processes and study the non-producing mock-ups, following initial experience with the general topics and the demonstrations. In Treatment B, practice time was the time remaining which was allocated to the subjects to use the operational commercial plastics equipment to produce parts, following the initial experience with the general topics and the demonstrations. Figure 3 provides an explanation of the division of time and use of the equipment.

Figure 3

The Time Allocations for the Topics, Demonstrations and Practice Time Within the Two Treatments

Treatment A, Toys and Mock-ups

4 Hours	4 Hours	12 Hours
General Topics	Demonstrations	Study of Mock-ups and Practice with the Toys

Treatment B, Commercial Plastics Equipment

4 Hours	4 Hours	12 Hours
General Topics	Demonstrations	Practice with the Commercial Plastics Equipment

The practice time was divided into two segments, work time and observation time. The limited number of equipment stations made it necessary to assign the subjects to each item of equipment in pairs. One subject operated while the other observed.

The total work-observation (practice) time per subject per item of equipment was determined by the total practice time available per type of equipment divided by the number of subjects in the class. The total practice time available per type of equipment was a product of the total practice time and the number of items of that type available. Tables 1 and 2 present the allocations of time per student for content and method by treatment.

During the work time the subject operated the equipment using the materials allotted for this use. He made parts or projects which were evaluated by the instructor, although this evaluation was not a part of the present study.

During the observation time the subject watched his partner operate the equipment, he drew a diagram and wrote a description of the process for his notebook which was turned in at the conclusion of the treatment. Evaluation of the notebook was not a part of the study either. Observation time with the mock-ups was limited to viewing them, drawing the diagrams and writing the descriptions for the notebooks.

In order to allow equal practice time for each subject within each treatment the number of educational toys was controlled so that the subjects in Treatment A had equal access to each process as the subjects in Treatment B. A ratio of three educational toys in Treatment A to one commercial plastics machine in Treatment B was used.

Table 1

TIME ALLOTMENTS PER STUDENT FOR CONTENT AND METHODS BY TREATMENT AT ANTHONY

	Method								
	Gen. Top. Demon.etc. Both Trs.	Practical Application							
		Treatment A				Treatment B			
		No. Avail. Type Equip.	Work	Observe	(T)[#]	No. Avail. Type Equip.	Work	Observe	(T)
I. Introduction to Plastics Ind.									
A. History	30 "*								
B. Growth	30 "								
C. Importance	30 "								
D. Future	15 "								
E. Organization	15 "								
II. Intro. to Materials & Processes									
A. Types and Classes	45 "								
B. Names of Materials	45 "								
C. Basic Polymer Sci.	45 "								
D. Molding Processes	45 "								
III. Practical Experience									
A. Compression Molding	30 "	1-Molder Mock-up (a)**		30"	(30)	1-Comm. Molder	24"	24"	(48)
B. Injection Molding	30 "	3-Kenner Toy	70"	70"	(140)	1-Comm. Molder	24"	24"	(48)
C. Thermoforming	30 "	3-Mattel Toy	70"	70"	(140)	1-Comm. Molder	24"	24"	(48)
D. Welding	30 "	1-Mock-up (b)		30"	(30)	1-Comm. Welder	24"	24"	(48)
E. Heat Sealing	30 "	2-Mock-ups (c)		30"	(30)	2-Comm. Sealers	24"	24"	(48)
		(d)		30"	(30)		24"	24"	(48)
F. Acrylic Project	30 "								
		Subtotal	140	260	(400)	Subtotal	144	144	(288)
		Hand tools	320			Hand tools	432		
		Total	460	260	(720)	Total	576	144	(720)

* Time in minutes

** Letter in ( ) indicates identification of mock-up in Appendix E-1.
Average time allotments per item based on 30 students per class.

[#] (T) = Total

Table 2

TIME ALLOTMENTS PER STUDENT FOR CONTENT AND METHODS BY TREATMENT AT COMO PARK

	Method								
	Gen. Top. Demo.	Practical Application							
		Treatment A				Treatment B			
	Both Tr.	No. Type	Work	Observe	(T)#	No. Type	Work	Observe	(T)
I. Intro. to Plastics Industry									
A. History	30"*								
B. Growth	30"								
C. Importance	30"								
D. Future	15"								
E. Organization	15"								
II. Intro. to Materials & Processes									
A. Types and Classes	45"								
B. Names of Materials	45"								
C. Basic Polymer Sci.	45"								
D. Molding Processes	45"								
III. Practical Experience									
A. Compression Molding	30"	1-Mock-up (a)**		30"	(30)	1-Comm.Molder	28"	28"	(56)
B. Injection Molding	30"	3-Kenner Toys	86"	86"	(172)	1-Comm.Molder	28"	28"	(56)
C. Thermoforming	30"	3-Mattel Toys	86"	86"	(172)	1-Comm. Molder	28"	28"	(56)
D. Welding	30"	1-Mock-up (b)		30"	(30)	1-Comm. Molder	28"	28"	(56)
E. Heat Sealing	30"	2-Mock-ups (c)		30"	(30)	2-Comm. Heat	28"	28"	(56)
		(d)		30"	(30)	Sealers	28"	28"	(56)
		Subtotal	172"	292"	(464)	Subtotal	168"	168"	(336)
		Hand Tools	256"			Hand Tools	384"		
F. Acrylic Project	30"	Total	428"	292"	(720)	Total	552"	168"	(720)

* Time in minutes

** Letter in ( ) indicates identification of mock-up in Appendix E-1.
Average time allotments per item based on 25 students per class.

# (T) = Total

Filler Project. A filler project, which did not represent any of the industrial plastics concepts under study in this experiment, was required of each subject to provide for student activity while the subjects were not able to use a processing machine, a toy or to study a mock-up because these were in use. In other words it was a device to keep all the subjects busy all of the time. Subjects were told to place a priority on the use of the equipment, toys and mock-ups rather than the filler project. This project, an acrylic plastic windshield scraper of a standard design consisting mostly of hand operations, was not evaluated as a part of the study.

Time Schedule

Each treatment was limited to twenty clock hours plus time for the tests as previously described and illustrated (Figure 3). The time scheduled for each individual process or item of equipment in each treatment appears in Tables 1 and 2, on pages 82 and 83. The time used for the tests was allocated as follows: plastics pretest, one hour; MRMT pretest, fifteen minutes; plastics post-test, one hour; MRMT post-test, fifteen minutes; plastics retention test, one hour.

Treatment A was conducted from February 22 through March 24 at Anthony Junior High School and From February 16 through March 30, 1966, at Como Park Junior High School. Treatment B was conducted from April 11 through May 6 at Anthony and from April 13 through May 24, 1966 at Como Park Junior High School.

Treatment Groups

Treatment A groups were taught first in each school in order that the subjects would not know that they were taking part in an experiment. It was felt that if both treatments were conducted during the same period of time the subjects would know that one group was using the toys and mock-ups while the other was using the commercial plastics equipment since the same shops and instructors were employed for both treatments. The students who were to take part in the second treatment were attending class in adjacent shops. Even if the subjects had not told their friends from another treatment group what they were doing or using in class, the commercial plastics equipment was such that it would be difficult to hide from the subjects.

Most of the operational plastics equipment required special installation such as drains, water or compressed air, making it obvious to the subjects that something was being changed or something new was being added. Students of that age are very curious and ask many questions. This situation was avoided by having the equipment stored in a room inaccessible to the subjects and then set up, wired and made operational at the last minute between treatments. Actually, all this was accomplished during the spring vacation. The writer felt that this precaution would reduce the chance of the Hawthorne effect.

Both instructors were cautioned to refrain from leading the subjects into thinking the educational toys and mock-ups were inferior to the operational plastics equipment. It was felt that remarks such as "these toys will do, but better equipment is available" or "this is the best we could get, but operational plastics equipment is also available" and similar statements might belittle the toys and mock-ups and lead the subjects to think that they were just playing rather than learning when using them. For the purposes of the experiment, regardless of personal feelings and until proven otherwise, both types of equipment were assumed of equal value in teaching plastics concepts and were used that way.

Treatment A groups in each school were taught by the same instructors as the Treatment B groups. The treatment group which was not being taught the plastics unit first took an industrial arts course in graphic arts under another instructor during the same hour.

Each school was visited once each week to observe the content being taught, the methods employed and the student reactions in order to maintain equality between schools. The instructors exchanged two dimensional visual aids, used the same textbooks, films, filmstrips, charts and drawings. Each made comparable reading assignments during the unit and required similar drawings and notebooks to be turned in at the conclusion of the unit. The students made similar projects in each school and used the same types of plastic materials for the projects. The instructors called each other weekly to mediate problems and each had comparable plastics reference libraries with which to work. Both were presented with a copy of the New York Resource Unit in Plastics (1966) several months prior to the first treatments. Materials and lesson plans were developed from this unit in advance.

The student absentee rates were comparable between treatments at Anthony as shown in Table 3. The student absentee rate for Treatment B at Como Park was higher than for Treatment A as reported in Table 3. Absentee rates for Como Park, however, were higher than for Anthony. Records showed that no students who were present in school were absent or excused from class during the treatments.

Table 3

ABSENTEE RATES IN TIMES ABSENT PER STUDENT DURING THE TREATMENT

	Treatment	
	A	B
Anthony	$\overline{X}$ = .60 s = .63 N = 30	$\overline{X}$ = .62 s = .62 N = 29
Como Park	X = .97 s = 1.71 N = 47	X = 1.51 s = 3.96 N = 45

In the opinion of the investigator, the treatments at each school were structured alike, had the same content, were conducted identically and were comparable in all essential elements.

Population and Sample

Population

The population consisted of the entire eighth grade (boys) enrolled in the Susan B. Anthony Junior High School, 5757 Irving Avenue South, Minneapolis, and the entire eighth grade (boys) enrolled in the Como Park Junior High School, West Rose and North Grotto Streets, St. Paul, during the 1965-66 school year.

Sample

The sample selected from the population consisted of 61 students at Anthony and 102 at Como Park. Some subjects were eliminated through experimental mortality. The original sample was reduced to 59 at Anthony and 92 at Como Park. These subjects in each school were eliminated from the study because of missing test scores. One subject from each treatment at Anthony was eliminated because of missing Iowa Test of Basic Skills scores. Six subjects at Como Park were eliminated for the same reason, three from each treatment. The other four subjects eliminated at Como Park were from Treatment B. They were removed from the study because of missing plastics criterion test scores. Data for the subjects eliminated from the study are reported in Tables 4 and 5.

Table 4

ANALYSIS OF THE MEAN PRETEST SCORES OF THE SUBJECTS ELIMINATED AND RETAINED FROM THE TREATMENTS AT ANTHONY JUNIOR HIGH SCHOOL

	Treatment	
	A	B
Subjects Eliminated	$\bar{X}$ = 32 N = 1	$\bar{X}$ = 41 N = 1
Subjects Retained	$\bar{X}$ = 35.7 N = 30	$\bar{X}$ = 34.5 N = 29

Table 5

ANALYSIS OF THE MEAN PRETEST SCORES OF THE SUBJECTS ELIMINATED AND RETAINED FROM THE TREATMENTS AT COMO PARK JUNIOR HIGH SCHOOL

	Treatment	
	A	B
Subjects Eliminated	$\bar{X}$ = 36 N = 3	$\bar{X}$ = 28 N = 7
Subjects Retained	$\bar{X}$ = 32.9 N = 47	$\bar{X}$ = 30.5 N = 45

All criterion test measure means were based upon the final sample size after the scores of the twelve subjects who were eliminated were withdrawn. Based on the pretest information, the subjects eliminated at Anthony might have influenced the results slightly in favor of Treatment B while those eliminated at Como Park seemed little different than the final sample used.

The Anthony sample was made up of two sections, one section for each treatment. The Como Park sample consisted of four sections, two for each treatment.

Selection of the Sample

The students in each school were assigned to each class section by an administrator in the respective schools. Random assignment of subjects to treatment groups by the investigator was not possible because the principals required that the treatments be fitted into the existing schedules without rearranging of student schedules.

Suitable test measures of student ability were available in both schools and were compatible. The Iowa Test of Basic Skills, Form 1, Eighth Grade, was administered to the entire population of both schools by the guidance departments during September, 1965, after which student composite grade equivalent scores were computed. This was the only ability test administered by both school systems at the time from which comparable scores of student ability could be obtained.

The Iowa Test of Basic Skills consisted of all eleven separate measures normally associated with this test. The test was organized as follows:

- Test V: Vocabulary
- Test R: Reading Comprehension
- Test L: Language Skills
    - L-1: Spelling
    - L-2: Capitalization
    - L-3: Punctuation
    - L-4: Usage
- Test W: Work-Study Skills
    - W-1: Map Reading
    - W-2: Reading Graphs and Tables
    - W-3: Knowledge and Use of Reference Materials
- Test A: Arithmetic Skills
    - A-1: Arithmetic Concepts
    - A-2: Arithmetic Problem Solving

The raw score from each test was converted into a grade equivalent score. Average grade equivalent scores for tests L, W and A were then computed. A composite grade equivalent score was computed for each student by averaging the average grade equivalent scores from tests V, R, L, W and A.

The administration of this test followed the prescribed procedure as described in Chapters 2 and 3 of the teacher's manual for the Iowa Test of Basic Skills (1964). The tests were scored mechanically at the State University of Iowa where the composite grade equivalent scores were computed as described above and in

Chapter 4 of the teacher's manual. Thus, the scores represented an average achievement of the tests described.

Table 6 shows that the combined groups (Treatment A and Treatment B) at Anthony had a mean grade equivalent score of 94.54 or 9th grade, 5th month, while the combined groups at Como Park had a mean of 43.67 or 4th grade, 4th month. The difference between the combined groups at Anthony and the combined groups at Como Park was 50.58 or about five grade equivalent years.

Analysis of the Iowa Test of Basic Skills mean grade equivalent scores from both schools revealed that the subjects in the combined groups at Anthony differed significantly from the subjects in the combined groups at Como Park as shown in Table 6.

Anthony. According to Mr. Robert Rutt, counselor at Anthony Junior High, the eighth grade male population was randomly assigned by office clerks to five sections of eighth grade industrial arts metal classes. Two of these sections were randomly assigned to the first school semester and three sections to the second semester. Two of the latter three industrial arts metal sections were chosen by the investigator to be used in the experiment.

The investigator chose one of the sections later assigned Treatment A, because it was the only one Mr. Means taught during the third nine-weeks of the school year. The other section, later assigned to Treatment B, was one of the remaining two

Table 6

SUMMARY OF THE ANALYSIS OF THE MEAN GRADE EQUIVALENT SCORES, IOWA TEST OF BASIC SKILLS, EIGHTH GRADE, FORM 1, AT ANTHONY AND COMO PARK JUNIOR HIGH SCHOOLS

Treatment	School		Overall
	Como Park	Anthony	
A	$\bar{X}$ = 45.29 s = 30.39 N = 47	$\bar{X}$ = 98.46 s = 13.22 N = 30	$\bar{X}$ = 66.01 s = 36.15 N = 77
B	$\bar{X}$ = 41.97 s = 30.51 N = 45	$\bar{X}$ = 90.48 s = 17.67 N = 29	$\bar{X}$ = 60.98 s = 35.35 N = 74
Totals	$\bar{X}$ = 43.67 s = 30.33 N = 92	$\bar{X}$ = 94.54 s = 15.45 N = 59	$\bar{X}$ = 63.55 s = 35.73 N = 151

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Between	1	93016.61	93016.61	140.72	$<.01$
Within	149	98486.87	660.99		

sections normally assigned to another industrial arts teacher during the fourth nine-weeks. This section was selected because it was available in the afternoon as was the Treatment A section which was taught earlier in the school year. The Treatment B section was then taught by Mr. Means during the fourth nine-week period.

The combined treatment group (two sections) was divided into high, middle and low ability levels according to their ITBS grade equivalent score. Approximately one-third of the total number of subjects were at each ability level.

Analysis of the ITBS grade equivalent scores at Anthony showed that while nearly one grade equivalent year different, the class assigned to Treatment A was not significantly different from the class assigned to Treatment B. A summary of the mean grade equivalent scores for Anthony are reported in Table 7.

Como Park. Students at Como Park were assigned to industrial arts courses by a technique which has been described as forced distribution. According to Mr. Fred Kaiser, counselor at Como Park, the students in the population were rated by their core teachers when they were in the seventh grade on a judgmental rating scale of 4, 3, 2 or 1. The teacher had each student two hours per day for a full year.

Eighth grade core sections were set up with equal distributions of students ranked 4, 3, 2 and 1 assigned to each core

Table 7

SUMMARY OF THE ANALYSIS OF THE IOWA GRADE EQUIVALENT SCORES AT ANTHONY JUNIOR HIGH SCHOOL

Ability Level	Treatment		Overall
	A	B	
High	$\bar{X}$ = 108.79 s = 4.71 N = 14	$\bar{X}$ = 110.40 s = 4.67 N = 5	$\bar{X}$ = 109.21 s = 4.50 N = 19
Middle	$\bar{X}$ = 98.50 s = 3.89 N = 8	$\bar{X}$ = 99.25 s = 3.65 N = 12	$\bar{X}$ = 98.95 s = 3.57 N = 20
Low	$\bar{X}$ = 80.38 s = 9.05 N = 8	$\bar{X}$ = 73.42 s = 13.86 N = 12	$\bar{X}$ = 76.20 s = 12.08 N = 20
Totals	$\bar{X}$ = 98.46 s = 13.22 N = 30	$\bar{X}$ = 90.48 s = 17.67 N = 29	$\bar{X}$ = 94.54 s = 15.45 N = 59

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	30.67	30.67	00.49	ns
Ability	2	9955.91	4977.95	79.60	<.01
Treatment x Ability	2	201.88	100.94	1.61	ns
Error	53	3314.60	62.53		

section by random selection. The eighth grade core sections were then split into three sub-sections with equal numbers of students assigned from each rank rating by a sorting technique in which every third student was placed into each sub-section. Four of these sub-sections were used as treatment groups. The first two sub-sections, the two eighth grade sections assigned to Mr. Bichner in the winter twelve-week period, were chosen for Treatment A and the second two sub-sections, Mr. Bichner's spring twelve-week period sections, were chosen for Treatment B.

The combined treatment groups were again divided into three ability levels of approximately equal size. Analysis of the ITBS grade equivalent scores at Como Park showed no significant difference in ability means between the Combined Treatment A group and the Combined Treatment B group. As expected a significant difference was found among the ability level means for the ITBS scores.

Although the students were not randomly assigned to the treatment groups by the investigator, it was concluded from the above analysis that the treatment groups were formed by essentially ramdom procedures and were comparable within schools at the beginning of the experiment.

Table 8 contains the data for Como Park.

Table 8

SUMMARY OF THE ANALYSIS OF THE GRADE EQUIVALENT SCORES, IOWA TEST OF BASIC SKILLS, AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment		Overall
	A	B	
High	$\overline{X}$ = 79.61 s = 14.21 N = 18	$\overline{X}$ = 78.13 s = 15.96 N = 16	$\overline{X}$ = 78.91 s = 14.63 N = 34
Middle	$\overline{X}$ = 33.93 s = 9.45 N = 15	$\overline{X}$ = 33.53 s = 10.68 N = 13	$\overline{X}$ = 33.75 s = 9.67 N = 28
Low	$\overline{X}$ = 13.36 s = 5.44 N = 14	$\overline{X}$ = 12.69 s = 3.94 N = 16	$\overline{X}$ = 13.00 s = 4.55 N = 30
Totals	$\overline{X}$ = 45.29 s = 30.39 N = 47	$\overline{X}$ = 41.97 s = 30.51 N = 45	$\overline{X}$ = 43.67 s = 30.33 N = 92

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	16.45	16.45	.13	ns
Ability	2	72779.24	36389.62	298.14	$<.01$
Treatment x Ability	2	5.08	2.54	.02	ns
Error	86	10496.84	122.06		

Data Collection

Plastics

The criterion plastics test for prior learning, initial learning, and retention was administered during school hours in the respective schools by the instructors, to gather data concerning the three dimensions under study. Students were allowed one hour to take the test each time, an amount determined adequate. Digitek DS 1120-C answer sheets were used and were scored mechanically by the Student Counseling Bureau. Raw scores were furnished to the cooperating teachers on print-out sheets from the Digitek scoring system. These raw scores were recorded on master forms by the investigator on which the subjects were identified by code numbers. The information was transferred to data cards and verified at the Numerical Analysis Center for future analysis. The test measures were collected in the following manner.

Prior Learning. Prior learning was tested by the criterion test instrument administered as a pretest one day prior to the beginning of each treatment and was used to determine if the subjects possessed any prior knowledge of plastics concepts.

Initial Learning. Initial learning was tested by the criterion test instrument administered as a post-test one day after the completion of the treatments and was used to determine how much the subjects learned about plastics concepts during the treatment.

Retention. Retention of knowledge of plastics concepts was tested by the criterion test instrument administered as a retention test two weeks after the completion of the treatments. It was used to determine how much knowledge of plastics concepts the subjects retained.

Transfer of Knowledge. Nineteen transfer of knowledge items were included in the criterion test instrument which was administered three times as described above. The scores of each measure reflected the transfer of knowledge of plastics concepts learned to somewhat novel situations in other industrial material areas.

Manual Dexterity

The Minnesota Rate of Manipulation Test (MRMT), placing and turning, was administered as a pretest and post-test to determine the amount of gain in development of manual dexterity by each subject during the treatment.

The MRMT was described by Flieshman (1962), Tinker and Wallace (1958), Buros (1965) and the examiner's manual for the MRMT (Bretts and Zeigler, 1957) as a test of manual dexterity. In Chapter V of Training Research and Education, edited by Robert Glazer (1962), Flieshman stated that the ability measured by the MRMT:

> . . . involves the skillful, well directed arm-hand movements in manipulating fairly large objects under speed conditions . . . . This ability appears to support performance on tasks requiring tool manipulation, assembly of large components, and wrapping of packages. The Minnesota Rate of Manipulation Test, which is commercially available, is the most frequently used test of this ability.

MRMT Placing Test. The placing test was given to each subject one day prior to the treatment and one day after the conclusion of the treatment allowing him to use either the right or the left hand, whichever proved most convenient. This was permitted because it was recognized that subjects would use the hand normally employed for this type of exercise.

MRMT Turning Test. The turning test was administered to each subject following the placing test and used the same procedures as the placing test. Each subject was allowed to use either the right or the left hand as the lead hand for the reasons given above.

Procedures and Scoring the MRMT Tests. Both MRMT tests were administered to each subject in accordance with the standard procedures which are detailed in the MRMT examiner's manual. The subjects were timed by five University Industrial Education student teachers under the supervision of the investigator. Each student teacher-timer clocked two subjects simultaneously using separate stop watches for each subject.

One practice trial and four timed trials were allowed each subject for each of the two tests. Scores were recorded on standard MRMT score sheets in seconds and tenths of seconds for each of the four timed trials for each test. An average of the four timed trials for each test was recorded for each subject.

The MRMT test boards and block sets were borrowed from the Psychology Department of the University.

Analysis

The analysis of the criterion test measures for plastics was performed by two-way analysis of variance techniques utilizing the UMSTAT 61 computer program and checked by hand. The analysis of the criterion tests for manual dexterity was performed by two-way analysis of variance or two-way analysis of covariance techniques utilizing the UMSTAT 61 and UMSTAT 50 computer programs. The UMSTAT 53 computer program was used to determine the correlations between all measures.

All computer programs were conducted with the advice and guidance of Dr. Douglas Anderson at the Numerical Analysis Center.

In each case where analysis of variance of analysis or covariance or correlational techniques were used in this study the five percent level of significance has been used as the level of significance for the rejection of the null hypothesis.

CHAPTER IV

FINDINGS AND TESTS OF HYPOTHESES

Introduction

The subjects in the two schools were found to be markedly different in initial mean ability and variability, as measured by the ITBS. These data are reported in Table 6 on page 93. The reader will recall from that table that the mean ITBS grade equivalent scores were 50.58 points, or approximately five grade equivalent years, different between the two schools, hence the difference in initial ability. In addition, the subjects at Como Park took 50 percent longer to complete the treatments (six weeks compared to four weeks) as the groups at Anthony.

Initially, the Como Park schedule called for classes to meet four hours per week and the Anthony schedule allowed five hours per week for the classes in which the experiment took place. Due to the great number of extra assembly programs and other interruptions, however, it was found that the instruction in the plastics unit at Como Park averaged about three and one-half hours per week instead.

It was decided, therefore, that the data from the two schools should be analyzed separately.

Mean scores on the plastics pretest for the high, middle and low ability sub-groups within each treatment group at both schools were near the guessing factor which was 25 percent or 29 points for a four element, multiple choice test with 116 items.

A two-way analysis of variance of the plastics pretest scores was performed for each school and these data are reported in Tables 9 and 10. No significant differences in prior learning (Hypothesis 1) were detected (a) between the treatments at either school, (b) among ability levels at Anthony and (c) in patterns of means within each school (interaction). A significant difference among ability levels however, was found at Como Park.

It was felt that these results indicated the groups of subjects studied had little or no prior knowledge of plastics concepts and that they were, for purposes of this study, naive. It was concluded that little advantage would be secured by using the plastics pretest score to correct the later criterion measurements for the prior differences in the groups.

Findings from both schools are presented and discussed in this chapter. Plastics test data from the groups at both schools were processed using analysis of variance and intercorrelation techniques. The MRMT data from the groups at both schools were processed using analysis of variance, analysis of covariance, and intercorrelation techniques.

Table 9

SUMMARY OF THE ANALYSIS OF THE PLASTICS PRETEST SCORES AT ANTHONY JUNIOR HIGH SCHOOL

Ability Level	Treatment		Overall
	A	B	
High	$\bar{X}$ = 37.71 s = 5.34 N = 14	$\bar{X}$ = 35.00 s = 6.63 N = 5	$\bar{X}$ = 37.00 s = 5.49 N = 19
Middle	$\bar{X}$ = 34.50 s = 6.07 N = 8	$\bar{X}$ = 37.83 s = 8.44 N = 12	$\bar{X}$ = 36.50 s = 7.40 N = 20
Low	$\bar{X}$ = 33.37 s = 4.20 N = 8	$\bar{X}$ = 31.00 s = 4.20 N = 12	$\bar{X}$ = 31.95 s = 4.15 N = 20
Total	$\bar{X}$ = 35.70 s = 5.46 N = 30	$\bar{X}$ = 34.51 s = 7.16 N = 29	$\bar{X}$ = 35.11 s = 6.33 N = 59

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	4.47	4.47	.12	ns
Ability	2	202.61	101.30	2.81	ns
Treatment x Ability	2	105.35	52.67	1.46	ns
Error	53	1906.40	35.97		

Table 10

SUMMARY OF THE ANALYSIS OF THE PLASTICS PRETEST SCORES AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment A	 B	Overall
High	$\bar{X} = 34.55$ s = 4.71 N = 18	$\bar{X} = 34.87$ s = 5.57 N = 16	$\bar{X} = 34.70$ s = 4.99 N = 34
Middle	$\bar{X} = 29.93$ s = 5.02 N = 15	$\bar{X} = 31.46$ s = 5.55 N = 13	$\bar{X} = 31.11$ s = 5.21 N = 28
Low	$\bar{X} = 30.50$ s = 4.64 N = 14	$\bar{X} = 25.13$ s = 7.77 N = 16	$\bar{X} = 27.63$ s = 6.84 N = 30
Total	$\bar{X} = 32.89$ s = 5.14 N = 47	$\bar{X} = 30.55$ s = 7.26 N = 45	$\bar{X} = 30.24$ s = 6.44 N = 92

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	2731.46	31.46	.98	ns
Ability	2	768.29	384.14	11.99	$<.01$
Treatment x Ability	2	201.52	100.76	3.14	ns
Error	86	2755.60	51.99		

Findings

The balance of the hypotheses tested and the results obtained follow.

> Hypothesis 2. On the initial learning test, there are no differences (a) between treatment means, (b) among ability level means and (c) between patterns of means within each treatment (interaction).

The data for question two are presented in Tables 11 and 12.

The difference observed of 0.45 points in favor of Treatment A for initial learning at Anthony was not significant. A significant difference, 13.65 points in favor of Treatment B, was detected for initial learning at Como Park.

As would be expected, significant differences were detected between ability levels for initial learning at both Anthony and Como Park. Mean initial learning scores were higher in Treatment B for each ability level at each school.

The interaction between the treatments and ability levels for initial learning at Anthony was not significant. A significant interaction was found, however, between treatments and ability levels at Como Park. There was a difference, favoring Treatment B, at each ability level. The differences were not of the same magnitude, however, resulting in the significant interaction. The largest difference in means (23.17) occurred in the

Table 11

SUMMARY OF THE ANALYSIS OF THE PLASTICS INITIAL LEARNING SCORES (POST-TEST) AT ANTHONY JUNIOR HIGH SCHOOL

Ability Level	Treatment		Overall
	A	B	
High	$\bar{X}$ = 69.21 s = 11.34 N = 14	$\bar{X}$ = 78.00 s = 13.66 N = 5	$\bar{X}$ = 71.52 s = 11.93 N = 19
Middle	$\bar{X}$ = 61.50 s = 11.99 N = 8	$\bar{X}$ = 65.33 s = 8.49 N = 12	$\bar{X}$ = 63.80 s = 9.66 N = 20
Low	$\bar{X}$ = 45.87 s = 7.38 N = 8	$\bar{X}$ = 48.33 s = 13.75 N = 12	$\bar{X}$ = 47.35 s = 11.15 N = 20
Totals	$\bar{X}$ = 60.93 s = 14.18 N = 30	$\bar{X}$ = 60.48 s = 16.04 N = 29	$\bar{X}$ = 60.71 s = 15.00 N = 59

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	330.37	330.37	2.62	ns
Ability	2	6139.27	3069.63	24.37	$<.01$
Treatment x Ability	2	89.23	44.61	.35	ns
Error	53	6676.57	126.00		

Table 12

SUMMARY OF THE ANALYSIS OF THE
PLASTICS INITIAL LEARNING SCORES (POST-TEST)
AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\bar{X}$ = 51.39 s = 11.55 N = 18	$\bar{X}$ = 74.56 s = 12.85 N = 16	$\bar{X}$ = 62.29 s = 16.53 N = 34
Middle	$\bar{X}$ = 38.27 s = 6.88 N = 15	$\bar{X}$ = 49.54 s = 16.02 N = 13	$\bar{X}$ = 43.50 s = 12.86 N = 28
Low	$\bar{X}$ = 31.07 s = 7.35 N = 14	$\bar{X}$ = 39.31 s = 13.56 N = 16	$\bar{X}$ = 35.46 s = 11.50 N = 30
Totals	$\bar{X}$ = 41.15 s = 12.40 N = 47	$\bar{X}$ = 54.80 s = 20.65 N = 45	$\bar{X}$ = 47.82 s = 18.20 N = 92

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	4606.31	46606.31	33.16	$<.01$
Ability	2	12964.78	6482.38	44.66	$<.01$
Treatment x Ability	2	1001.54	500.77	3.60	$<.05$
Error	86	11946.75	138.92		

high ability group while the smallest difference in means (8.24) occurred in the low ability group. The reader should recall that the low ability groups at Como Park had mean grade equivalent scores which were very low, averaging first grade, third month for the combined low ability groups from Treatments A and B. The mean initial learning scores for the low ability level of the combined Treatments A and B at Como Park was only 7.83 points above the mean prior learning (pretest) scores for the low ability level of the combined Treatments A and B.

> Hypothesis 3. On the retention test, there are no differences (a) between treatment means, (b) among ability level means and (c) between patterns of means within each treatment (interaction).

The data for question three are reported in Tables 13 and 14.

The difference observed of 1.59 points in favor of Treatment B for retention at Anthony was significant. The difference observed of 13.75 points in favor of Treatment B for retention at Como Park was also significant.

As would be expected, significant differences between ability levels for retention were detected at both Anthony and Como Park. Mean retention scores were higher in Treatment B for each ability level at each school.

Table 13

SUMMARY OF THE ANALYSIS OF THE PLASTICS RETENTION SCORES AT ANTHONY JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\bar{X}$ = 66.07 s = 12.21 N = 14	$\bar{X}$ = 73.40 s = 19.19 N = 5	$\bar{X}$ = 68.00 s = 13.78 N = 19
Middle	$\bar{X}$ = 52.25 s = 11.41 N = 8	$\bar{X}$ = 62.83 s = 8.50 N = 12	$\bar{X}$ = 58.60 s = 10.59 N = 20
Low	$\bar{X}$ = 39.38 s = 8.85 N = 8	$\bar{X}$ = 44.08 s = 9.51 N = 12	$\bar{X}$ = 42.20 s = 9.08 N = 20
Totals	$\bar{X}$ = 55.30 s = 15.7 N = 30	$\bar{X}$ = 56.89 s = 15.8 N = 29	$\bar{X}$ = 56.08 s = 15.66 N = 59

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	743.61	743.61	5.92	$< .05$
Ability	2	6703.08	3351.54	26.66	$< .01$
Treatment x Ability	2	83.11	41.56	.33	ns
Error	53	6662.09	125.70		

Table 14

SUMMARY OF THE ANALYSIS OF THE PLASTICS RETENTION SCORES AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment		Overall
	A	B	
High	$\overline{X} = 50.22$ s = 14.26 N = 18	$\overline{X} = 72.06$ s = 15.62 N = 16	$\overline{X} = 60.50$ s = 18.11 N = 34
Middle	$\overline{X} = 34.87$ s = 6.85 N = 15	$\overline{X} = 44.46$ s = 17.54 N = 13	$\overline{X} = 39.21$ s = 13.35 N = 28
Low	$\overline{X} = 26.86$ s = 4.79 N = 14	$\overline{X} = 38.38$ s = 11.30 N = 16	$\overline{X} = 33.00$ s = 10.34 N = 30
Totals	$\overline{X} = 38.36$ s = 13.90 N = 47	$\overline{X} = 52.11$ s = 21.01 N = 45	$\overline{X} = 45.08$ s = 18.90 N = 92

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	4736.01	4736.01	29.77	<.01
Ability	2	14265.64	7132.82	44.83	<.01
Treatment x Ability	2	760.91	380.45	2.39	ns
Error	86	13680.47	159.08		

There was no significant interaction between the treatments and ability levels for retention at either school.

Hypothesis 4. On manual dexterity (placing and turning), there are no differences (a) between treatment means, (b) among ability level means and (c) between patterns of means within each treatment (interaction).

The data for question four are reported in Tables 15 through 20. In interpreting the Minnesota Rate of Manipulation Test (MRMT) scores it must be remembered these scores are time scores so the lower scores are the better scores, a reverse of the plastics test scores where the higher scores are the better scores.

Anthony

The data for the MRMT pretest and the MRMT post-test were analyzed by analysis of variance techniques.

Placing. The difference in means on the MRMT placing pretest at Anthony of 2.06 seconds in favor of Treatment A was not significant. The difference in means on the MRMT placing post-test at Anthony, 2.26 seconds in favor of Treatment A, was not significant.

The differences in means among ability levels on the MRMT placing pretest and the MRMT placing post-test at Anthony were not significant.

No significant interaction between the treatment means and the ability level means, for the MRMT placing pretest and the MRMT placing post-test at Anthony, was detected.

Data for the Anthony placing pretest are reported in Table 15 and the placing post-test in Table 16.

Turning. The difference in means on the MRMT turning pretest at Anthony of 0.55 seconds in favor of Treatment A was not significant. The difference in means on the MRMT turning post-test at Anthony of 0.40 seconds in favor of Treatment A was also not significant.

The differences in means among ability levels on the MRMT turning pretest at Anthony were not significant. The differences in means among ability levels on the MRMT turning post-test at Anthony were not significant.

No significant interaction between the treatment means and the ability level means on the MRMT turning pretest and the MRMT turning post-test was detected.

Data for the Anthony MRMT turning pretest are reported in Table 17 and the MRMT turning post-test in Table 18.

Como Park

The data for the MRMT pretests were analyzed by analysis of variance techniques.

Placing. The difference in means on the MRMT placing pretest at Como Park of 2.47 seconds in favor of Treatment B was significant.

Table 15

SUMMARY OF THE ANALYSIS OF THE MRMT PLACING PRETEST
AT ANTHONY JUNIOR HIGH SCHOOL

Ability Level	Treatment		Overall
	A	B	
High	$\bar{X}$ = 50.35 s = 4.73 N = 14	$\bar{X}$ = 50.94 s = 3.72 N = 5	$\bar{X}$ = 50.50 s = 4.28 N = 19
Middle	$\bar{X}$ = 49.38 s = 7.42 N = 8	$\bar{X}$ = 51.61 s = 5.24 N = 12	$\bar{X}$ = 50.72 s = 5.96 N = 20
Low	$\bar{X}$ = 53.37 s = 5.72 N = 8	$\bar{X}$ = 55.12 s = 5.93 N = 12	$\bar{X}$ = 54.42 s = 5.61 N = 20
Total	$\bar{X}$ = 50.89 s = 5.96 N = 30	$\bar{X}$ = 52.95 s = 5.62 N = 29	$\bar{X}$ = 51.90 s = 5.73 N = 59

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	30.37	30.37	.97	ns
Ability	2	166.74	83.37	2.68	ns
Treatment x Ability	2	5.77	2.88	.09	ns
Error	53	1649.39	31.12		

Table 16

SUMMARY OF THE ANALYSIS OF THE MRMT PLACING POST-TEST
AT THE ANTHONY JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\bar{X}$ = 46.79 s = 4.53 N = 14	$\bar{X}$ = 49.11 s = 3.81 N = 5	$\bar{X}$ = 47.3 s = 4.2 N = 19
Middle	$\bar{X}$ = 48.00 s = 3.27 N = 8	$\bar{X}$ = 48.85 s = 5.52 N = 12	$\bar{X}$ = 48.5 s = 4.5 N = 20
Low	$\bar{X}$ = 49.30 s = 5.62 N = 8	$\bar{X}$ = 51.65 s = 6.94 N = 12	$\bar{X}$ = 50.7 s = 6.2 N = 20
Total	$\bar{X}$ = 47.79 s = 4.74 N = 30	$\bar{X}$ = 50.05 s = 6.05 N = 29	$\bar{X}$ = 48.9 s = 5.3 N = 59

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	44.03	44.03	1.57	ns
Ability	2	64.61	32.31	1.14	ns
Treatment x Ability	2	6.80	3.40	.12	ns
Error	53	1486.48	28.05		

Table 17

SUMMARY OF THE ANALYSIS OF THE MRMT TURNING PRETEST AT THE ANTHONY JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\bar{X}$ = 43.58 s = 4.77 N = 14	$\bar{X}$ = 42.18 s = 1.43 N = 5	$\bar{X}$ = 43.21 s = 4.05 N = 19
Middle	$\bar{X}$ = 42.00 s = 4.45 N = 8	$\bar{X}$ = 40.77 s = 4.55 N = 12	$\bar{X}$ = 41.25 s = 4.32 N = 20
Low	$\bar{X}$ = 42.38 s = 8.11 N = 8	$\bar{X}$ = 46.51 s = 7.92 N = 12	$\bar{X}$ = 44.85 s = 7.85 N = 20
Total	$\bar{X}$ = 42.83 s = 5.62 N = 30	$\bar{X}$ = 43.38 s = 6.40 N = 29	$\bar{X}$ = 43.11 s = 5.97 N = 59

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	3.27	3.27	.09	ns
Ability	2	89.93	44.96	1.31	ns
Treatment x Ability	2	90.73	45.36	1.32	ns
Error	53	1821.68	34.37		

Table 18

SUMMARY OF THE ANALYSIS OF THE MRMT TURNING POST-TEST AT THE ANTHONY JUNIOR HIGH SCHOOL

Ability Level	Treatment		Overall
	A	B	
High	$\bar{X}$ = 36.31 s = 3.12 N = 14	$\bar{X}$ = 35.10 s = 2.51 N = 5	$\bar{X}$ = 35.98 s = 2.88 N = 19
Middle	$\bar{X}$ = 35.07 s = 3.17 N = 8	$\bar{X}$ = 34.91 s = 3.27 N = 12	$\bar{X}$ = 34.97 s = 3.06 N = 20
Low	$\bar{X}$ = 36.20 s = 4.80 N = 8	$\bar{X}$ = 38.31 s = 5.34 N = 12	$\bar{X}$ = 37.46 s = 4.98 N = 20
Total	$\bar{X}$ = 35.95 s = 3.71 N = 30	$\bar{X}$ = 36.35 s = 5.22 N = 29	$\bar{X}$ = 36.04 s = 4.05 N = 59

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	.80	.80	.05	ns
Ability	2	51.25	25.63	1.66	ns
Treatment x Ability	2	25.02	12.51	.81	ns
Error	53	815.87	15.39		

The differences in means among ability levels on the MRMT placing pretest at Como Park were significant.

No significant interaction between the treatment means and the ability level means for the MRMT placing pretest was detected.

Data for the Como Park MRMT placing pretest are reported in Table 19.

Turning. The difference in means on the MRMT turning pretest at Como Park of 3.11 seconds in favor of Treatment B was significant.

The differences in means among ability levels on the MRMT turning pretest at Como Park were significant.

No significant interaction between the treatment means and the ability level means for the MRMT turning pretest was detected.

Data for the Como Park MRMT turning pretest are reported in Table 20.

The data for the MRMT placing and turning post-tests for Como Park are reported in Tables 21 and 22.

After the preliminary analysis of the data for the Como Park MRMT placing and turning pretests it was decided that the straightforward analysis of variance would not be appropriate because of the significant differences in the means of the MRMT pretests favoring Treatment B. An analysis of covariance was performed using the pretest score as a covariant. The results of this analysis are presented in Tables 23 and 24.

Table 19

SUMMARY OF THE ANALYSIS OF THE MRMT PLACING PRETEST
AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\bar{X}$ = 53.51 s = 3.05 N = 18	$\bar{X}$ = 53.20 s = 5.11 N = 16	$\bar{X}$ = 53.36 s = 4.02 N = 34
Middle	$\bar{X}$ = 57.56 s = 4.40 N = 15	$\bar{X}$ = 51.79 s = 3.82 N = 13	$\bar{X}$ = 54.88 s = 4.92 N = 28
Low	$\bar{X}$ = 58.80 s = 4.74 N = 14	$\bar{X}$ = 56.35 s = 5.79 N = 16	$\bar{X}$ = 57.49 s = 5.29 N = 30
Total	$\bar{X}$ = 56.38 s = 4.55 N = 47	$\bar{X}$ = 53.91 s = 5.30 N = 45	$\bar{X}$ = 55.16 s = 5.17 N = 92

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	184.19	184.19	8.83	$<.01$
Ability	2	291.36	145.68	6.98	$<.05$
Treatment x Ability	2	114.05	57.02	2.73	ns
Error	86	1793.54	20.86		

Table 20

SUMMARY OF THE ANALYSIS OF THE MRMT TURNING PRETEST AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\overline{X} = 44.11$ $s = 3.39$ $N = 18$	$\overline{X} = 40.44$ $s = 4.30$ $N = 16$	$\overline{X} = 42.38$ $s = 4.15$ $N = 34$
Middle	$\overline{X} = 47.74$ $s = 5.38$ $N = 15$	$\overline{X} = 42.72$ $s = 3.73$ $N = 13$	$\overline{X} = 45.41$ $s = 5.16$ $N = 28$
Low	$\overline{X} = 48.70$ $s = 4.99$ $N = 14$	$\overline{X} = 47.22$ $s = 7.66$ $N = 16$	$\overline{X} = 47.91$ $s = 6.37$ $N = 30$
Total	$\overline{X} = 46.61$ $s = 5.49$ $N = 47$	$\overline{X} = 43.50$ $s = 6.39$ $N = 45$	$\overline{X} = 45.10$ $s = 5.87$ $N = 92$

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	260.84	260.84	9.97	$<.01$
Ability	2	513.58	256.79	9.81	$<.01$
Treatment x Ability	2	46.50	23.25	.89	ns
Error	86	2249.56	26.16		

Table 21

SUMMARY OF THE ANALYSIS OF THE MRMT PLACING POST-TEST AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\bar{X}$ = 47.10 s = 2.95 N = 18	$\bar{X}$ = 49.33 s = 3.15 N = 16	$\bar{X}$ = 48.14 s = 3.15 N = 34
Middle	$\bar{X}$ = 52.15 s = 4.18 N = 15	$\bar{X}$ = 48.69 s = 3.29 N = 13	$\bar{X}$ = 50.54 s = 4.04 N = 28
Low	$\bar{X}$ = 53.13 s = 4.25 N = 14	$\bar{X}$ = 51.20 s = 4.86 N = 16	$\bar{X}$ = 52.10 s = 4.62 N = 30
Total	$\bar{X}$ = 50.51 s = 4.61 N = 47	$\bar{X}$ = 49.80 s = 4.08 N = 45	$\bar{X}$ = 50.16 s = 4.35 N = 92

Marginal means are weighted means.

Table 22

SUMMARY OF THE ANALYSIS OF THE MRMT TURNING POST-TEST AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\overline{X}$ = 35.90 s = 3.73 N = 18	$\overline{X}$ = 35.97 s = 3.77 N = 16	$\overline{X}$ = 35.93 s = 3.63 N = 34
Middle	$\overline{X}$ = 38.85 s = 3.10 N = 15	$\overline{X}$ = 36.37 s = 3.77 N = 13	$\overline{X}$ = 37.70 s = 3.52 N = 28
Low	$\overline{X}$ = 39.73 s = 5.02 N = 14	$\overline{X}$ = 39.65 s = 5.60 N = 16	$\overline{X}$ = 39.68 s = 4.54 N = 30
Total	$\overline{X}$ = 37.98 s = 4.28 N = 47	$\overline{X}$ = 37.39 s = 4.86 N = 45	$\overline{X}$ = 37.68 s - 4.56 N = 92

Marginal means are weighted means.

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Table 23

SUMMARY OF THE ANALYSIS OF THE ADJUSTED MRMT PLACING POST-TEST SCORES AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\bar{X} = 25.37$ N = 18	$\bar{X} = 27.73$ N = 16	$\bar{X} = 26.47$ N = 34
Middle	$\bar{X} = 28.77$ N = 15	$\bar{X} = 27.66$ N = 13	$\bar{X} = 28.26$ N = 28
Low	$\bar{X} = 29.25$ N = 14	$\bar{X} = 28.32$ N = 16	$\bar{X} = 28.76$ N = 30
Total	$\bar{X} = 27.61$ N = 47	$\bar{X} = 27.91$ N = 45	$\bar{X} = 27.76$ N = 92

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	11.5	11.5	.97	ns
Ability	2	85.0	42.5	3.59	ns
Treatment x Ability	2	102.3	51.15	4.32	$<.05$
Error	85	1006.5	11.84		

Table 24

SUMMARY OF THE ANALYSIS OF THE ADJUSTED MRMT TURNING POST-TEST SCORES AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment A	Treatment B	Overall
High	$\overline{X}$ = 9.64 N = 18	$\overline{X}$ = 11.89 N = 16	$\overline{X}$ = 10.70 N = 34
Middle	$\overline{X}$ = 10.43 N = 15	$\overline{X}$ = 10.94 N = 13	$\overline{X}$ = 12.66 N = 28
Low	$\overline{X}$ = 10.74 N = 14	$\overline{X}$ = 11.54 N = 16	$\overline{X}$ = 11.15 N = 30
Total	$\overline{X}$ = 10.22 N = 47	$\overline{X}$ = 11.49 N = 45	$\overline{X}$ = 10.83 N = 92

Marginal means are weighted means

ANALYSIS OF VARIANCE TABLE

SV	df	SS	MS	F	P
Treatment	1	124.6	124.6	8.52	$<.01$
Ability	2	68.5	34.25	2.34	ns
Treatment x Ability	2	68.5	34.5	2.34	ns
Error	85	1242.6	14.62		

Placing. No significant differences in means between treatments was detected for the MRMT placing post-test at Como Park after correction for initial differences by covariance.

No significant differences in means among ability levels were detected for the MRMT placing post-test at Como Park after correction for initial differences by covariance.

However, a significant interaction between the treatment means and the ability level means was detected for the MRMT placing post-test at Como Park after correction by covariance.

The adjusted means for the low and middle ability levels were better in Treatment B than in Treatment A while the adjusted means for the high ability level and the total adjusted mean for Treatment A were better. The difference in adjusted means for the high ability level was 2.36 seconds better in favor of Treatment B, 1.11 seconds for the middle ability level and 0.93 seconds for the low ability level. This crossover caused the significant interaction.

Turning. A significant difference in means between treatments of 1.27 seconds in favor of Treatment A was detected for the MRMT turning post-test at Como Park after correction for initial differences by covariance.

No significant differences in means among ability levels were detected for the MRMT turning post-test at Como Park after correction for initial differences by covariance.

No significant interaction between treatment means and ability level means was detected for the MRMT turning post-test at Como Park after correction for initial differences by covariance.

> Hypothesis 5. For the prior learning and initial learning tests, there are no differences between the means of the tests at each ability level for each treatment.

Because this was an experiment where the six groups at each school were given content over a considerable period of time, it was of interest to determine if all the groups scored significantly higher on the initial learning test (post-test) than they did on the prior learning test (pretest). The significance of the difference in means between the pretest and the post-test was determined by a subject by treatment analysis of variance technique. This subject by treatment analysis equates to a "t" test for means of correlated measures as discussed in Walker and Lev, Statistical Inference, pages 151-4.

Significantly higher mean post-test scores were recorded at each ability level in each treatment at each school with the exception of the low ability group in Treatment A at Como Park.

In the low ability group in Treatment A at Como Park a difference in means of less than one point between the plastics pretest and plastics post-test was observed. The smallest difference in means reported for any other group was more than eight points which was reported for the middle ability group in the same treatment at Como Park.

One should recall from Chapter III that the mean ITBS score for this low ability group was very low. It should also be noted that seven of the fourteen subjects in the low ability group in Treatment A had above average absentee rates. These seven students averaged 36 days per year of absence while the average for the entire student body at Como Park was 15 days per year for the 1965-66 school year. In addition, three students in this group were extreme discipline cases and in the opinion of the instructor, one student "did nothing."

Data for the differences in means between the plastics pretest and the plastics post-test are reported in Tables 25 and 26.

> Hypothesis 6. For each pair of measures within each treatment at each school, there is no linear relationship between the measures.

Analysis of the intercorrelations among variables revealed significant positive relationships between ability (ITBS) and initial learning and retention measures of plastics concepts for both treatments at both schools.

Significant positive relationships between the plastics post-test and plastics pretest were detected for both treatments

Table 25

SUMMARY OF THE ANALYSIS OF THE DIFFERENCES IN MEANS BETWEEN THE PLASTICS PRETEST AND PLASTICS POST-TEST AT ANTHONY JUNIOR HIGH SCHOOL

Ability Level	Treatment		Overall
	A	B	
High	$\overline{D}$ = 31.50* N = 14	$\overline{D}$ = 43.00* N = 5	$\overline{D}$ = 34.52 N = 19
Middle	$\overline{D}$ = 27.00* N = 8	$\overline{D}$ = 27.50* N = 12	$\overline{D}$ = 27.30 N = 20
Low	$\overline{D}$ = 12.50* N = 8	$\overline{D}$ = 17.33* N = 12	$\overline{D}$ = 15.40 N = 20
Total	$\overline{D}$ = 25.23 N = 30	$\overline{D}$ = 25.97 N = 29	$\overline{D}$ = 25.60 N = 59

*Significant.

Table 26

SUMMARY OF THE ANALYSIS OF THE DIFFERENCES IN MEANS BETWEEN THE PLASTICS PRETEST AND THE PLASTICS POST-TEST AT COMO PARK JUNIOR HIGH SCHOOL

Ability Level	Treatment		Overall
	A	B	
High	$\bar{D}$ = 16.84* N = 18	$\bar{D}$ = 39.69* N = 16	$\bar{D}$ = 27.59 N = 34
Middle	$\bar{D}$ = 8.34* N = 15	$\bar{D}$ = 18.08* N = 13	$\bar{D}$ = 13.00 N = 28
Low	$\bar{D}$ = 0.57 N = 14	$\bar{D}$ = 14.18* N = 16	$\bar{D}$ = 7.83 N = 30
Total	$\bar{D}$ = 8.26 N = 47	$\bar{D}$ = 24.25 N = 45	$\bar{D}$ = 16.66 N = 92

*Significant

Marginal means are weighted means.

at both schools. Significant positive relationships between the plastics pretest and the plastics retention test were detected in all the groups except the Treatment B group at Como Park. Significant positive relationships were detected between the plastics pretest and the ITBS in all the groups except Treatment B at Anthony.

Significant positive relationships were detected between the MRMT pretest and the MRMT post-test measures on both placing and turning for both treatments at both schools.

As might be expected, no significant positive relationship was detected between the MRMT tests and the plastics tests or the ability measures (ITBS). Significant negative relationships between the MRMT measures and the plastics measures were detected in some groups, but no definite pattern was established. These negative relationships should be interpreted as positive, however, because the higher ability scores were the better scores while the lower manual dexterity scores were the better scores.

Tables 27 through 30 provides the correlation matrices for each treatment at each school.

Table 27

CORRELATION MATRIX FOR ALL SCORES FOR TREATMENT "A" AT ANTHONY JUNIOR HIGH SCHOOL

Test	MRMT Pre Placing (1)	MRMT Pre Turning (2)	MRMT Post Placing (3)	MRMT Post Turning (4)	Plastics Pre (5)	Plastics Post (6)	Plastics Retention (7)	ITBS (8)
1) MRMT Pre Placing	1.0000							
2) MRMT Pre Turning	.6027**	1.0000						
3) MRMT Post Placing	.6948**	.4904**	1.0000					
4) MRMT Post Turning	.6455**	.8673**	.5986**	1.0000				
5) Plastics Pretest	-.0111	.0189	.0934	.0197	1.0000			
6) Plastics Post-Test	-.2496	-.1013	-.2811	-.1546	.4236*	1.0000		
7) Plastics Retention	-.2702	.0636	-.3011	-.1196	.4752**	.8402**	1.0000	
8) ITBS	-.3195	-.1437	-.3428	-.2434	.3752*	.7518**	.7709**	1.0000

Correlations greater than .3493 are significant at the .05 level (*) and .4487 at the .01 level (**).

Table 28

CORRELATION MATRIX FOR ALL SCORES FOR TREATMENT "B" AT ANTHONY JUNIOR HIGH SCHOOL

Test	MRMT Pre Placing (1)	MRMT Pre Turning (2)	MRMT Post Placing (3)	MRMT Post Turning (4)	Plastics Pre (5)	Plastics Post (6)	Plastics Retention (7)	ITBS (8)
1) MRMT Pre Placing	1.0000							
2) MRMT Pre Turning	.8184**	1.0000						
3) MRMT Post Placing	.9091**	.8020**	1.0000					
4) MRMT Post Turning	.8112**	.8903**	.7963**	1.0000				
5) Plastics Pretest	-.2200	=.1219	=.1352	-.0909	1.0000			
6) Plastics Post-Test	-.3577	-.2988	-.2820	-.3176	.3923*	1.0000		
7) Plastics Retention	-.3880*	-.3207	-.3024	-.3202	.4589**	.9284**	1.0000	
8) ITBS	-.4152*	-.4120*	-.3467	-.4561	.3459	.8584**	.8074**	1.0000

Correlations greater than .3494 are significant at the .05 level (*) and .4487 at the .01 level (**).

Table 29

CORRELATION MATRIX FOR ALL SCORES FOR TREATMENT "A" AT COMO PARK JUNIOR HIGH SCHOOL

Correlations greater than .2875 are significant at the .05 level (*) and .3721 at the .01 level (**).

Test	Correlation							
1) MRMT Pre Placing	1.0000							
2) MRMT Pre Turning	.6296*	1.0000						
3) MRMT Post Placing	.6849**	.4753**	1.0000					
4) MRMT Post Turning	.6953**	.6304**	.6212**	1.0000				
5) Plastics Pretest	-.2099	-.0755	-.1590	-.3058	1.0000			
6) Plastics Post-Test	-.4814**	-.4109**	-.5512	-.4091	.3516*	1.0000		
7) Plastics Retention	-.4717**	-.4200**	-.5342	-.3992	.3442*	.7720**	1.0000	
8) ITBS	-.5765**	-.4693	-.5953	-.5027	.3472*	.7827**	.7893**	1.0000
	MRMT Pre Placing (1)	MRMT Pre Turning (2)	MRMT Post Placing (3)	MRMT Post Turning (4)	Plastics Pre (5)	Plastics Post (6)	Plastics Retention (7)	ITBS (8)

Table 30

CORRELATION MATRIX FOR ALL SCORES FOR TREATMENT "B" AT COMO PARK JUNIOR HIGH SCHOOL

Test	MRMT Pre Placing (1)	MRMT Pre Turning (2)	MRMT Post Placing (3)	MRMT Post Turning (4)	Plastics Pre (5)	Plastics Post (6)	Plastics Retention (7)	ITBS (8)
1) MRMT Pre-Placing	1.0000							
2) MRMT Pre-Turning	.6601**	1.0000						
3) MRMT Post Placing	.7720**	.4423**	1.0000					
4) MRMT Post Turning	.6272**	.7704**	.5388**	1.0000				
5) Plastics Pretest	-.1466	-.2560	-.0956	-.1434	1.0000			
6) Plastics Post-Test	-.2300	-.3536*	-.3365	-.3685*	.3369*	1.0000		
7) Plastics Retention	-.1544	-.3039*	-.2122	-.2912*	.2485	.9088**	1.0000	
8) ITBS	-.1412	-.3957*	-.1157	-.2735	.4518**	.7591**	.7634*	1.000

Correlations greater than .3493 are significant at the .05 level (*) and .4487 at the .01 level (**).

Summary

In general, this study investigated the relative effectiveness of two types of plastics equipment in teaching the concepts of the plastics industry. Two schools were utilized and the subjects in both treatments were subdivided into three ability levels according to their Iowa Test of Basic Skills grade equivalent score. This subdivision was done to determine the effects of the two treatments at the ability levels. A 2 x 3 two-way analysis design was used to determine the differences, if any, between the treatments. The significant findings are presented separately for each school.

A number of conclusions have been made based on the findings presented in this chapter. From these conclusions several implications for education are drawn and suggestions for further research presented.

Conclusions

The following conclusions are based on the results of the tests provided by this study of the hypotheses posed in Chapter I, as objectives. The conclusions are based on, and limited to, the samples used and the conditions prevailing during the study, or to similar hypothetical situations.

1. On the basis of the plastics pretest scores, it was concluded that the students' prior knowledge of plastics concepts at each school was:

   - (a) not significantly different between treatments,
   - (b) significantly different among ability levels at Como Park but not at Anthony,
   - (c) not significantly different in patterns of means between treatments (interaction).

   In addition it was concluded that, since the mean plastics pretest scores were at or near the guessing factor for both schools, the subjects had little prior knowledge of plastics concepts.

2. From the evidence gathered by the plastics post-test, it was concluded that the students' initial learning of plastics concepts at Anthony was:
   - (a) not significantly different between treatments,
   - (b) significantly different among ability levels,
   - (c) not significantly different in patterns of means between treatments (interaction).
3. It was concluded, from the scores obtained from the plastics post-test at Como Park, that the students' initial learning of plastics concepts was:
   - (a) significantly different between treatments in favor of the commercial plastics equipment.
   - (b) significantly different among ability levels,
   - (c) significantly different in patterns of means between treatments (interaction).

4. From the scores obtained from the plastics retention test, it was concluded that the students' retention of plastics concepts at both schools was:
   (a) significantly different between treatments in favor of commercial plastics equipment,
   (b) significantly different among ability levels,
   (c) not significantly different in patterns of means between treatments (interaction).
5. On the basis of the scores from the pretest and post-test measures of the Minnesota Rate of Manipulation Test, placing and turning tasks, it was concluded that the students' development of manual dexterity at Anthony was:
   (a) not significantly different between treatments,
   (b) not significantly different among ability levels,
   (c) not significantly different in patterns of means between treatments (interaction).
6. From the analysis of the adjusted scores of the Minnesota Rate of Manipulation Tests at Como Park, it was concluded that the students' development of manual dexterity for the placing task was:
   (a) not significantly different between treatments,
   (b) not significantly different among ability levels,
   (c) significantly different in patterns of means between treatments (interaction).

and for the turning task was:

(a) significantly different between treatments in favor of the commercial equipment,

(b) not significantly different among ability levels,

(c) not significantly different in patterns of means between treatments (interaction).

7. It was concluded, from a comparison of the plastics pretest and post-test scores, that the students from all ability levels in each treatment at each school, with the exception of the low ability level in Treatment A (toys and mock-ups) at Como Park, gained significantly in knowledge of plastics concepts during the conduct of the treatments.

8. The intercorrelation of all scores from all the criterion measures provided data from which it was concluded that there was:

(a) a significant relationship (positive) between the plastics pretest, post-test and retention scores except for the pretest-retention test relationship for Treatment B at Como Park.

(b) a significant relationship (positive) between all plastics test scores and the Iowa Test of Basic Skills scores except for the pretest-ITBS relationship for Treatment B at Anthony.

(c) a negative relationship between the MRMT scores and both the plastics and the ITBS scores, which established no specific pattern of significance or non-significance.

Discussion of the Conclusions

The investigator proposes several possible explanations for the lack of significant differences between treatments for initial learning at Anthony.

One possible explanation might be student excitement over other school activities prior to the post-test for Treatment B (commercial equipment). A check of school records revealed that on Thursday, Friday and Saturday evenings prior to the post-test, which was taken on Monday, the school operetta was performed. Some of the students in Treatment B were involved in the operetta and many of the others attended it. In addition, a party was held for a number of these students in a private home following the operetta on Saturday night. Conversations with several school personnel revealed that the students were extremely tired and very quiet on the day of the test. The excitement of the three days of the operetta, the rehearsals and preparations prior to it and the party afterwards with their effect on the study and sleep habits of the student body may have caused the Treatment B group to do less well than expected on the post-test. Activities of this type at Anthony were termed unusual by school personnel and no such activities were scheduled during Treatment A.

This suggests that the Treatment B group might have done better than they did on the post-test.

Another interesting factor to consider as contributory to the low post-test mean score for Treatment B at Anthony was the paper sale scheduled for the Wednesday following the post-test. Students were issued rope for the paper sale on the morning of the test.

A factor which could also have caused some difference in the achievement of the Treatment B group was the initial ability of the students. There was a greater difference in initial ability, in favor of Treatment A although not significant, between the two treatment groups at Anthony than there was at Como Park prior to the treatments. This greater difference, coupled with the other factors cited above, may have contributed to the small post-test difference detected between treatments at Anthony.

Motivation is another factor which may have caused the more obvious differences between treatments in initial learning and retention of plastics concepts at Como Park. The lower ability students, who were more prevalent at Como Park, seemed to be more highly motivated by the commercial plastics equipment than the toys and mock-ups. Evidence of this appears in the letter from Mr. Bichner (Appendix D-1). The subjects at Anthony (especially in Treatment A), on the other hand, were higher ability students and were probably able to grasp the concepts from abstract experiences (toys and mock-ups) more easily. This may have contributed to the less obvious differences detected at Anthony for the post-test.

According to Mr. Means and Mr. Bichner (Appendix D), some of the educational toys and mock-ups seemed more effective than others. The subjects became discouraged with the Kenner injection molder toy because it was slow to heat up, slow to heat plastic and produced poor parts. The material used broke easily and was difficult to remove from the molds. The subjects did not care to spend time studying the mock-ups when the educational toys were available or when they could work on their filler project. This discouragement and lack of interest was probably transformed into reduced motivation in Treatment A. The Mattel Vac-U-Form toy was effective and did perform well, however.

The subjects appeared to be more enthusiastic and interested in plastics concepts when using the commercial equipment. It appeared to motivate the low ability students more than the toys and mock-ups.

Several observations concerning the outcomes of the study seem appropriate. The first deals with the ability level at which the students seemed to gain most from the treatments, the second with the test and the last with the effect of this study on industrial arts in Minneapolis and St. Paul.

The higher ability groups appeared to learn more initially and retain more when using the commercial plastics equipment, when compared with those who used the toys and mock-ups, than either of the other ability groups. In addition, the higher ability groups in each treatment appeared to gain more from the pretest to the post-test than the middle or low ability groups. The highest ability group in each school appeared to learn the most regardless of their actual mean ability.

Since desirable gains in the learning of plastics concepts were detected in all but one group, the total program seemed effective. The one exception was the low ability group in Treatment A at Como Park. This group apparently was not motivated sufficiently as it gained less than one point in mean scores from pretest to post-test.

A second observation concerning the study was in regard to the plastics test developed for the study. It seemed sufficiently sensitive for initial learning and retention. It could serve as a model for tests covering similar courses.

The last observation concerns the effect the study seemed to have on the Minneapolis and St. Paul school systems. Although it was not a part of the present research, one outcome was the establishment of pilot programs in plastics instruction at the junior high school level in these two school systems. This experiment stimulated other instructors to develop an interest in teaching plastics units. It also served as a stimulus for the people in the respective school systems to pruchase plastics equipment for other junior high schools.

The investigator also recognized several factors which might influence the outcomes of such a study. Included are absentee rates, teacher practice and the sequence of treatments.

Absentee rates, if higher in one treatment than the other, might affect the outcome as higher rates probably would tend to lower achievement. The rates for both treatments at Anthony were essentially the same so probably had little effect on the criterion scores. The absentee rate for Treatment B at Como Park, the treatment with the higher initial learning and retention scores, was higher than for Treatment B. This would tend to indicate that this factor did not contribute to the higher mean scores obtained in Treatment B.

Teacher practice might also effect the outcome of the experiment since both treatments were taught by the same instructor. A teacher with no previous experience in the subject might tend to do a better job the second time he taught the course. However, Mr. Bichner, who taught at Como Park where the greatest differences between treatments were observed, had previous experience teaching plastics. Mr. Means at Anthony, where smaller differences were observed, had never taught plastics before. It was felt that teacher practice had little affect on the outcome of this study.

The sequence of treatments might have had an effect on the results of the study. One should recall that in both schools Treatment A was conducted first. Had Treatment B been conducted first in one of the schools, different results might have been obtained. It was recognized, however, that if Treatment B was done first in either school it was more likely that the subjects would discover that they were taking part in an experiment. Equipment for use in Treatment B needed installation such that it became semi-permanent and would likely remain in the shop while Treatment A was being conducted. In addition, the students who were to take part in the second treatment were in an adjacent shop during the first treatment period. If the equipment remained in the shop or if the students from the other group saw it through the doorway between shops, it could invite questions, the answers to which might produce the Hawthorne effect. It was felt by the investigator that this factor would influence the outcomes of the study more than the advantage of a reverse sequence in one school.

Implications

As a result of this study some implications for teaching plastics concepts in a beginning course at the junior high school level were drawn.

1. Commercial plastics equipment (Type 2) should be utilized whenever possible for teaching concepts in a beginning course at the junior high level and especially for low ability students.
2. Educational toys and three dimensional, non-producing mock-ups (Type 4) may be employed with caution in a beginning,

exploratory industrial arts plastics course for teaching concepts, realizing that these will be less effective than commercial equipment especially with low ability students.

3. The evidence suggested that the educational toys and three dimensional, non-producing mock-ups might have provided less motivation than the commercial equipment, especially for the low ability student. Caution should be exercised in the use of toys and mock-ups when a large proportion of low ability students are present. Additional motivational devices may be necessary to produce the desired results under such conditions.

Suggestions for Further Research

Evidence gathered and observations made during the conduct of this study have suggested areas of additional research which might prove profitable.

1. The concern of the present study was the relative effectiveness of educational toys and three dimensional, non-producing mock-ups compared with that of commercial equipment in teaching plastics concepts. Several other comparisons in this same area are possible. Research should be conducted to compare the relative effectiveness of:
   (a) educational toys with that of mock-ups,
   (b) commercial equipment with that of industrial production equipment,

(c) educational toys with that of industrial production equipment,

(d) mock-ups with that of industrial production equipment,

(e) educational toys with commercial equipment in other industrial areas. One such suggestion involves woodworking where toy power homeworkshops are available.

2. Since this study was conducted with boys only, research similar to it and to the above suggestions should be conducted in which both boys and girls are involved.

3. The present study did not probe into the relationship between industrial arts and the development of manual dexterity. It might prove interesting to conduct a comparative study of industrial arts and non-industrial arts students to determine if the former contributes to the development of manual dexterity.

4. The present study was limited to the teaching of plastics concepts in industrial arts. A study to determine how educational toys and mock-ups effect the learning of concepts in other disciplines such as business education, home economics, mathematics and science should prove fruitful.

5. Since this study was conducted in the junior high school, a similar study at the senior high school level should be conducted.

6. The present research should be replicated to determine if the conflicting results obtained for initial learning of plastics concepts would reoccur.

7. There was some evidence to suggest that the low ability students were not well motivated by the educational toys and mock-ups. While other factors may be involved, further research seems necessary to ascertain whether
    (a) this condition does in fact exist
    (b) the seriousness of the condition
    (c) what motivational factors, if any, could be employed to alleviate this deficiency.
8. Research should be conducted to determine what differences, if any, should exist between the various types of equipment needed for junior high exploratory, senior high general, senior high unit, high school and post high school vocational and college teacher training courses.

BIBLIOGRAPHY

BIBLIOGRAPHY

American Industrial Arts Association, American Council of Industrial Arts Supervisors, Industrial Arts Education. Washington, D.C.: Author, 1963.

American Industrial Arts Association. A Guide for Equipping Industrial Arts Education Facilities, Washington, D.C.: Author, 1967.

American Vocational Association. A Guide to Improving Instruction in Industrial Arts, Washington, D.C.: Author, 1953.

American Vocational Association. Industrial Arts in Education. Washington, D.C.: Author.

Anderson, Roy H. A Course of Study for Plastics, Grade 7. Ellis Junior High School, Austin, Minnesota, mimeographed.

Baird, R. J. The Application of John Dewey's Philosophy to Industrial Arts Teacher Education. Unpublished Ed.D. dissertation, Michigan State University, East Lansing, 1960, 265 pp.

Bennett, Charles A. History of Manual and Industrial Education up to 1870. Peoria, Ill.: Chas. A. Bennet Co., Inc., 1926, 460 pp.

Bennett, Charles A. History of Manual and Industrial Education, 1890-1917. Peoria, Ill.: Chas. A. Bennett Co., Inc., 1937, 566 pp.

Bjorkquist, David. Discrimination transfer from scale models and pictorial drawings in learning orthographic projection. Unpublished Ph.D. dissertation, University of Minnesota, Minneapolis, Minnesota, 1965.

Bloom, Benjamin S. Taxonomy of Educational Objectives (Cognitive Domain). New York, N.Y.: David McKay Co., Inc., 1956.

Bonde, R. G. An Evaluation of Selected Elementary School Industrial Arts Hand Tools - Grade I. Unpublished Ed.D. dissertation, Colorado State College, 1964.

Bretts, Gilbert L. and Zeigler, W. A. Examiner's Manual, *Minnesota Rate of Manipulation Test*. Minneapolis, Minn.: Educational Test Bureau, 1957, pp. 16.

Bruner, Jerome S. *The Process of Education*, Cambridge, Mass.: Harvard Univ. Press, 1963.

Buros, Oscar, Ed. *6th Mental Measurements Yearbook*, Hyland Park, N.J.: Gryphen Press, 1965. (MRMT p. 1077)

Cantor, Robert L. A study of the industry and field of plastics as a creative medium for avocational and vocational uses of the layman. Unpublished Ph.D. dissertation, New York University, New York, 1952.

Dale, Edgar. *Audio Visual Methods in Teaching*, *Revised*. New York: Dryden Press, 1954, pp. 534.

Dattman, Priscilla E. and Israel, Harold E. The order of dominance among conceptual capacities: an experimental test of Heidbreder's hypothesis, *Journal of Psychology*, 1951, *31*, 147-160.

De Vore, Paul. *Technology*, *an Intellectual Discipline*. Washington, D.C.: American Industrial Arts Association, 1964.

Dewey, John. *Experience and Education*, New York: Macmillan Co., 1939.

Dewey, John. *Democracy and Education*. New York: Macmillan Co., 1963, 378 pp.

Doutt, Richard. An evaluation of selected elementary school industrial arts hand tools, Grades II, III and IV, Unpublished Ed.D. dissertation, Colorado State College, Greeley, 1965.

Encyclopedia of Educational Research, rev. ed., New York: Macmillan Co., 1950, pp. 177.

Erickson, Emanual E. *Teaching the Industrial Arts*. Peoria, Ill.: Chas. A. Bennett Co., 1946, pp. 384.

French, Thomas E. and Vierch, Charles J. *Engineering Drawing*, *8th Ed*., New York: McGraw-Hill Co., 1953, pp. 715.

Gagne, Robert. The Conditions of Learning. New York: Holt, Rinehart & Winston, Inc., 1965, 308 pp.

Glazer, Robert, Ed., Training Research and Education. Univ. of Pittsburgh Press, Pittsburgh,Pa, 1962. 596 pp. Fleishman, Chapter 5, The description and prediction of perceptual-motor skill learning, A. Fleishman, Ed., Yale Univ. Press. 143 pp.

Golomb, Arthur E. A guide to plastics in the industrial arts program of the Academic High Schools of New York City. Unpublished Ed.D. dissertation, New York Univ., New York, 1962.

Hansen, R. G. An evaluation of selected elementary school industrial arts hand tools - Grades II and III. Unpublished Ed.D. dissertation, Colorado State College, 1964.

Harsha, Paul. Profiles in industry, plastics, Industrial Arts and Vocational Education, Milwaukee, Wisconsin, November 1960, p. 43.

Hatch, James. Plastics Course of Study, Gates Chili Senior High School, Rochester, New York, unpublished.

Heidbreder, Edna. Toward a dynamic psychology of cognition, Psychological Review, January 1945, 52, 1-22.

Heidbreder, Edna. The attainment of concepts: I Terminology and Methodology, Journal of General Psychology, 1946, 35.

Heidbreder, Edna. The attainment of concepts: II. The Problems, Journal of General Psychology, 1946, 35, 191-223. (b)

Heidbreder, Edna. The attainment of concepts: III. The Process, Journal of Psychology, 1947, 24, 93-138.

Iowa, State University of. Teachers manual, Iowa Tests of Basic Skills, Boston, Mass.: Houghton Mifflin Co., 1964, 91 pp.

Johnson, Ira and Anderson, Ronald. Plastics in industrial arts, American Vocational Journal, January 1961, p. 20.

Kingsley, H. L. and Garry, R. The Nature and Conditions of Learning, 2nd edition, Englewood Cliffs, N.J.: Prentice-Hall, 1957, 565 pp.

Lappin, Alvin. An evaluation of procedures for introducing new materials, tools and processes in industrial arts teacher education. Unpublished Ed. D. dissertation, Wayne State University, Detroit, Michigan, 1958, 226 pp.

McBeath, R. J. A comparative study on the effectiveness of the filmstrip, sound filmstrip and filmograph for teaching facts and concepts. Unpublished Ph.D. dissertation, University of Southern California, 1961, 144 pp.

Maley, Donald. Some imperatives through industrial arts. Speech to American Vocational Association, Minneapolis, December 1964.

Melton, Arthur W. Categories of Human Learning, N.Y.: Academic Press, 1964.

Micheels, William J. Industrial Arts Education, Bulletin #1, American Industrial Arts Association, Washington, D.C.

Miller, Neal, et al. Graphic communication and the crisis in education, Audio Visual Communication Review, December 1957,1-120.

Minnesota State Department of Education. A guide for instruction in industrial arts. Curric. Bul. 13 Revised, St. Paul, Minn., 1962, 172 pp.

ok

Nair, Ralph K., Ed. Planning Industrial Arts Facilities, Equipment Section, Chapter V., Eighth Yearbook, 1959, American Council on Industrial Arts Teacher Education, Bloomington, Ill.: Mc Knight & McKnight Publishing Co.

New York State, An Experimental Resource Unit in Plastics for Industrial Arts. Bureau of Secondary Curriculum Development, University of New York State, Albany, N.Y., 1966.

New York State, Organization and Administration of Industrial Arts Education, Bureau of Industrial Arts Education, State Dept. of Education, New York: University of the State of N.Y., 1960.

Olson, Delmar. Industrial Arts and Technology, Inglewood Cliffs, N.J.: Prentice Hall, 1963.

Roberts, Roy W. Vocational and Practical Arts Education, 2nd Edition, New York: Harper & Row, 1965.

Rogers, William W. Technical Education in Metals and Plastics. Faculty Student Corp. of the State Univ. Agriculture and Technical Inst., Farmingdale, L.I., New York, 1960.

Rokusek, R. J. An experimental comparison of the relative effectiveness of the automated lecture-graphic and programmed methods of teaching. Unpublished Ph.D. dissertation, 1964.

Runnalls, James J. Plastics technology and its reflection in industrial arts teacher education programs, Unpublished Ed.D. thesis, University of Missouri, Columbus, 1965.

Salomon, Otto. The Teachers Handbook of Sloyd, London: George Philip & Son, 1894, 269 pp.

Salomon, Otto, The Theory of Educational Sloyd, New York: Silver, Burdett & Co., 1907.

Schields, Robert. "Plastics: New Materials for a New Age," School Shop, Ann Arbor, Michigan, April 1962, 61 pp.

Schmitt, Marshall and Pelley, Albert. Industrial Arts Education. OE 33038-Circ. #791, U.S. Dept. of H.E.W., Washington, D. C., 1966, 138 pp.

Sevier, Vernetta. "Junior High School Experiments with Plastics." School Arts, November 1962.

Shell, Walter. Effectiveness of the diotype as an instructional device in first year typewriting. Unpublished Ph.D. dissertation, Ohio State University, Columbus, Ohio, 1965.

Smoke, Kenneth. "An Objective Study of Concept Formation," Psychological Monographs, 1932, 42, 1-46.

Society of the Plastics Industry, Inc., Plastics Education Guide, N.Y.: Author, 1966.

Society of the Plastics Industry, Inc., The Story of the Plastics Industry. N.Y.: Author, 1966.

Society of the Plastics Industry, Inc., Talking Plastics, a filmstrip. New York: Author.

Steele, Gerald L. "Teaching Plastics," Industrial Arts and Vocational Education, September 1964, 53, 31-33.

Steele, Gerald L. "An Introduction to Plastics," School Shop, November 1966, 324 pp.

Stein, Jess, Ed., The Random House Dictionary of the English Language. New York: Random House, 1966. 2059 pp.

Stout State University. Plastics: Industrial Products and Processes, a film. Stout State Univ., Menomonie, Wisconsin.

Swanson, Robert. Plastics Technology. Bloomington, Ill.: McKnight & McKnight, 1965.

Tinker, Miles A. and Russell,Wallace A. Introduction to Methods In Experimental Psychology, 3rd Edition, New York: Appleton-Century-Crofts Inc., 1958. Chapter XXX Exper. 22 Manual Dexterity.

Towers, Ray, Lux and Stern. Industrial Arts Curriculum Proposal, the Ohio State University, Columbus, Ohio, 1966. (tentative draft)

Trachtman, Bernie. Introduction to Plastics, a filmstrip. Wichita, Kansas: Kitco, Inc., 1965.

Vinacke, W. Edgar. The investigation of concept formation. Psychological Bulletin, January 1951, 48, pp. 1-31.

Walker, Helen M. and Lev, Joseph. Statistical Inference, Holt, Rinehart and Winston, New York, 1953, 510 pp.

Wall, G. S. Ed. Approaches and Procedures in Industrial Arts, fourteenth Yearbook, American Council on Industrial Arts Teacher Education, Bloomington, Ill.: McKnight & McKnight Publ. Co., 1965, 143 pp.

Webster's New Collegiate Dictionary, 2nd Edition, Springfield, Mass.: G. & C. Merriam Co., 1953.

Wenzel, Bernice M. and Flurry, Christine. The sequential order of concept attainment, Journal of Experimental Psychology, 1948, 38, 547-557.

Wilbur, Gordon O. Industrial Arts in General Education, Second Edition, International Textbook Co., Scranton, Pa., 1954, 401 pp.

Master's Theses on Plastics Curriculum

Brill, Donald M. A guide for teaching plastics, Master's thesis, University of Minnesota, 1949.

Edgar, Harold F. Plastics in the high school industrial arts curriculum, Master's thesis, Stout State University, Menomonie, Wisconsin, 1950.

Heggen, James. A proposed woods-plastics shop, Master's thesis, Stout State University, Menomonie, Wisconsin, 1959.

Jackson, Peter. The selection and classification of industrial instructional materials for use in secondary school plastics courses, Master's thesis, Stout State University, Menomonie, Wisconsin, 1959.

James, H. S. Jr. The development and use of plastics in industry with proposals for the adoption of plastics as a phase of industrial arts, Master's thesis, North Texas State College, Denton, Texas, 1951.

Nichmann, Harold, Plastics in industrial arts education, Master's thesis, Southwest Texas State Teachers College, San Marcos, 1947.

Pluckhon, Wayne. Reenforced plastics, Master's thesis, Stout State Univ., Menomonie, Wisconsin, 1958.

Schoeniki, Jerald W. In-service workshop program in plastics as a supervisory method for the upgrading of the plastics area in the industrial arts program, Master's thesis, Stout State University, Menomonie, Wisconsin, 1961.

Teschke, Theodore. A proposed resource unit in plastics for Wisconsin Schools, Master's thesis, Stout State University, Menomonie, Wisconsin, 1949.

Treise, Edward G. Equipment and procedures for a free blowing method of forming acrylic plastics, Master's thesis, Stout State University, Menomonie, Wisconsin, 1955.

APPENDIXES

Appendix A Test Evaluation Procedure

A-1 Letter of Inquiry

A-2 Outline of Units

A-3 Reply and Evaluation Form

A-4 Panel of Experts

A-5 Letter of Instruction to Panel

A-6 Procedure for Reviewing Test Items

A-7 Test Item Evaluation Form

Appendix A-1

University of Minnesota

College of Education
Department of Industrial Education
Minneapolis, Minnesota 55455
December 6, 1965

Dr. Robert Swanson, Dean
Applied Science and Technology
Stout State University
Menomonie, Wisconsin

Dear Dr. Swanson:

I am doing a research project entitled "A Comparison of Plastics Concepts Learned Using Educational Toys and Three Dimensional Models and Concepts Learned Using Commercial Plastics Processing Equipment", of which an abstract of the proposal is enclosed. This research is being done with the advice and approval of my major adviser, Dr. Howard F. Nelson, Professor and Chairman of the Industrial Education Department here.

In connection with this project, it will be necessary for me to test the students about the information covered in a plastics unit of about four weeks in length. Enclosed is a copy of the unit outline. Because tests for this unit are not available, I will need to develop and validate them. For this I will need a panel of experts in plastics education.

Would you serve as a member of this expert panel to help determine if these tests have construct validity? I will furnish you with a copy of the text, which I would like returned, a complete course outline, a complete set of objectives and a criteria sheet for judging the test items.

Your early reply to this request so that I may send out the materials as soon as they are complete will be greatly appreciated. I am enclosing a short information form I would like for you to use in your reply.

Thank you for your kind consideration of this matter.

Sincerely,

Gerald L Steele

Gerald L. Steele, Instructor
Industrial Education Department

GLS:pb
Enclosure

Appendix A-2

OUTLINE FOR UNITS FOR A PLASTICS COURSE, JUNIOR HIGH BEGINNING COURSE TO BE USED IN CONJUNCTION WITH A DOCTORAL STUDY BY GERALD L. STEELE, DEPARTMENT OF INDUSTRIAL EDUCATION

---

1. Introduction to the plastics industry
    - A. History of the industry
    - B. Growth of the industry
    - C. Importance of the industry
    - D. Future of the industry
    - E. Organization of the industry
2. Introduction to plastics materials and processes
    - A. Types of and classifications
    - B. Names of materials in general use
    - C. Basic polymer science--the long chain molecules
    - D. Outline of the molding processes
3. Plastics processes and materials, practical experience
    - A. Compression molding and transfer molding
    - B. Injection molding
    - C. Thermoforming
        - 1) Vacuum
        - 2) Blow
        - 3) Stretch
    - D. Welding
    - E. Heat sealing
    - F. Acrylic sheet forming (filler project only)

Appendix A-3

REPLY AND INFORMATION FORM

This form is designed for your reply to my request for your cooperation in establishing construct validity to the tests which I will design for my study as stated. This information will be used for nothing else and will be held in strictest confidence. You may use this form for your reply and place it in the self-addressed envelope to return it to me. Thank you for your time. Sincerely,

Gerald L Steele

Gerald L. Steele

Your Name ______________________________ Title ____________

College or Firm Address ____________________________________

____ Date _______

- -

*1. Do you now (this year) teach a course called plastics?Yes___;No ___

2. Have you ever taught a course called plastics? Yes___; No ___

3. Do you now (this year) teach a course called crafts or industrial crafts which includes plastics but is not exclusively plastics? Yes___;No___

4. Have you ever taught a course called crafts or industrial crafts which included plastics but was not exclusively plastics? Yes___;No___

5. Do you now believe that plastics is important enough to be taught as a separate course, including its many processes and materials (assuming that you could have a plastics shop and have the equipment you wanted in it)? Yes___;No___

6. Do you now believe that plastics should be taught as a craft subject, from the craft approach or as a part of a crafts course (assuming that you could have a plastics shop with the equipment you wanted)? Yes___;No___

7. Would you be willing to serve on the panel of experts to help establish construct validity for my tests to be used in the project as outlined and described in my letter and return the materials promptly? Yes___;No___

8. If you are willing to help me in this situation would you please help by first giving me some information about what you would include in a Basic Plastics Course at the freshman or sophomore college level if you could have the shop you wanted with the equipment that you want. Please indicate by filling in the second page of this form.

---

*If you are not a teacher note this and answer items as you think they should be taught.

NOTE: Units need not necessarily be organized in the following manner. A number of other patterns could be established. It was arranged in this manner for convenience. The content is what is important.

	YES	NO
I. Introduction to the industry	____	____
A. History of the industry	____	____
B. Growth of the industry	____	____
C. Importance of the industry	____	____
D. Future of the industry	____	____
E. Organization of the industry	____	____
F. ______________________	____	____
G. ______________________	____	____
II. Introduction to plastics materials and processes	____	____
A. Types and classifications of plastics	____	____
B. Names of materials in general use	____	____
C. Basic polymer science	____	____
D. Outline of molding processes	____	____
E. ______________________	____	____
III. Plastics processes & materials (practical Exper)	____	____
A. Compression & transfer molding	____	____
B. Injection molding	____	____
C. Extrusion and blow molding	____	____
D. Thermoforming (Vacuum, blow & Stretch)	____	____
E. Casting (Vinyl dispersion, thermofusion & rotational molding)	____	____
F. Coating processes (Cold dip & fluidized bed)	____	____
G. Lamination (Fiber glass & high & low pressure)	____	____
H. Foam Molding (Bead & resin)	____	____
I. Bonding (Welding, cementing & heat sealing)	____	____
J. Other ____________________________	____	____
IV. Identification and properties of plastics	____	____
A. Identification procedures	____	____
B. Properties (Mechanical, physical, electrical & chemical)	____	____
C. Testing of plastics properties	____	____

A. If you think other things should be added to the above please suggest them here.

B. If you think some of the items above, as for example #IV-B, should be eliminated, please indicate why you think so.

C. The text book PLASTICS TECHNOLOGY, by Robert Swanson will be used for the experimental course which you are being asked to help validate the tests for. Please indicate here if you do not have the text and if you want me to loan you one for the validation procedure.

Yes, I need a book ________ No, I do not ________

Appendix A-4

Panel of Experts

Dr. Robert Swanson
Dean
Applied Science and Technology
Stout State University
Menomonie, Wisconsin

Dr. Harlon Scherer
Industrial Arts Department
Bemidji State College
Bemidji, Minnesota

Mr. Lauton Edwards
Principal,
Von Guilder Occupational Training School
Knoxville, Tennessee

Mr. Clyde Hackler,
Assistant Professor
Industrial Arts Department
Morehead State College
Morehead, Kentucky

Dr. Henry Loats,
Professor,
Industrial Arts Department
Ball State University
Muncie, Indiana

Dr. Alvin Lappin
Professor,
Industrial Arts Department
San Jose College
San Jose, California

Mr. Maurice Keroack
Professor
Industrial Arts Department
State University College
Buffalo, New York

Dr. Vivian Stinnett
Associate Director
Research Triangle Institute
Camille Drefus Laboratory
Durham, North Carolina

Dr. Charles Bunten
Professor
Industrial Arts Department
Southern Illinois University
Carbondale, Illinois

Dr. Sam Porter, Professor
Industrial Arts Department
Western Washington State College
Bellingham, Washington

Dr. James Church,
Professor,
Chemical Engineering
Columbia University
New York, New York

Dr. Wayne Becker
Professor,
Industrial Arts Department
University of Wichita
Wichita, Kansas

Appendix A-5

University of Minnesota

College of Education
Department of Industrial Education
Minneapolis, Minnesota 55455

January 22, 1966

Dear Sir:

Thank you for your kind reply to my letter asking you to serve as a panel member to help me determine the validity of my plastics test which will be used as an evaluation device in conjunction with my doctoral study. I appreciate your willingness to help.

Enclosed are the materials for this task, which I hope will not be too burdensome. I have tried to arrange the work in such a manner as to provide for the maximum ease and speed. You will note that I have arranged the sheets to include the objectives to be taught on the left side of the page, the test items in the middle of the page and the columns for evaluation on the right side. A sheet of directions is provided to give procedures and criteria for judging. This is designed so that the maximum uniformity will result.

Because time between now and when I must first use this test is short, as it always seems to get, I hope that this task can be completed and returned to me in two weeks, ie. by about February 8th.

As I am sure that you would like copies of the test after it has been validated, I shall send you two copies for your own use. One caution, however, as this is being used for a doctoral dissertation it cannot appear in an article or be copyrighted as the University of Minnesota reserves that right. You will also be sent a copy of the results of the study when they become available.

Thank you again for your speedy reply to my first letter and your kind offer to help. Without you and others like you this would be an impossible task for me.

Sincerely,

Gerald L Steele

Gerald L. Steele, Instructor
Department of Industrial Education

GLS:pj
Enclosures

Appendix A-6

PROCEDURE FOR REVIEWING THE TEST MATERIAL

1. Please feel free to write on all the materials in the form of notes or suggestions.

2. Read the objectives stated in one area between the horizontal lines and then judge the test items for those objectives or objective. Judge each item for two things before moving to the next item, (1) for level according to Bloom's Taxonomy as described below and (2) for validity according to the criteria described in statement form below.

3. Judge the test item first as to level. If you agree with the level which I have assigned to the item put a + in the last column marked "Does it measure the level indicated". If you disagree with the level I have assigned, indicate with a 0 in the last column and then indicate in the "level" column what level that you would assign the item. You are only asked to judge the validity and level of the test items. You are to assume that the objectives are satisfactory as they have been developed specifically for the course to be taught.

STATEMENT OF LEVELS

The various levels of test items have been constructed to satisfy the definitions presented in Bloom's Taxonomy of Educational Objectives, (Cognitive Domain). Briefly the following definitions may be used for each level.

LEVEL I. Knowledge of terminology, specific facts, conventions, trends and sequences, classifications and categories, criteria, methodology, principles and generalizations, and theories and structures, ie. memorized facts of information.

LEVEL II. Understanding of interrelationships of memorized facts, specifics and abstractions learned.

LEVEL III. Transfer or application of knowledge and understandings into a situation somewhat different from which it was learned.

4. Judge the test item according to the following criteria and put a check (✓) mark in the proper evaluation column indicating your choice of either (1) good item, (2) revise item or (3) throw out. If, in your judgement, the item should be revised, according to the stated criteria, please indicate how it should be revised, ie. (a) cross out any alternative answers which you

think are not suitable and suggest a replacement, or (b) cross out and substitute a word or words which you think need changing. If the whole item needs revising suggest in general terms how it should be done. Most sheets have ample room for comment.

CRITERIA FOR JUDGING TEST ITEMS

GOOD ITEM. Item measures the objective stated and has four (4) suitable alternative answers.

REVISE ITEM. Item measures the objective but wording is poor or 1 to 3 of the alternative answers are not suitable. Suggest changes.

THROW OUT ITEM. Item does not measure the objective and/or all four alternative answers are not suitable.

5. State, on the back of the last sheet, any concepts or objectives which in your opinion have not been identified, if any. Consider, however, the following limitations: the course will be taught to eighth grade students for four weeks (20 class hours) with the following equipment available in addition to the normal junior high shop (one group in a wood shop and the other in a metal-electricity shop combination).

    1) Injection molder
    2) Compression molder
    3) Thermoformer
    4) Plastics welder
    5) Hand held heat sealer

6. Some items may satisfy more than one objective or a different one than stated. Some objectives may appear to have more than their share of test items. In this case only those judged best will be retained. Adjustments may have to be made to balance the number of items for each level, if so an effort will be made to retain those of higher level.

TEST ITEM EVALUATION FORM, PLASTICS

OBJECTIVES	TEST ITEMS	EVALUATION Level	Good item	Revise it	Throw it out	Does it measure level indicated?
Unit I. Introduction to the Plastics Industry Upon completion of this unit the student should be able to identify the following facts and information on a multiple choice criterion test.						
A. History of the Plastics Industry 1. The natural resinous materials which preceded the invention of plastics but act similar to plastics are a. natural rubber b. shellac	Two natural resinous materials which act similar to plastics but preceded the discovery of plastics are: a. wood and coal b. rubber and shellac c. alkyds and epoxies d. nylons and phenols	I				
2. The first commercial plastics invention a. cellulose nitrate (celluloid)	The worlds first commercial plastics material was: a. cellulose nitrate b. cellulose acetate c. phenol-formaldehyde d. nylon	I				
b. was discovered by John Wesley Hyatt in 1868	John Wesley Hyatt invented: a. the first commercial molding technique b. the second commercial plastic c. celluloid d. phenolics	I				

OBJECTIVES	TEST ITEMS	EVALUATION
c. was caused by the shortage of ivory for billiard balls	The first commercial plastics material was invented to: a. fill a shortage of shellac b. fill a shortage of ivory c. help a new printing technique d. fill a shortage of natural rubber	I
d. was used for the first photographic films, shirt collars, auto side curtain windows, etc.	The plastic material which was used for the first flexible photographic films was: a. shellac b. celluloid c. cellulose acetate d. phenolic	I
e. was flammable -- disadvantage	The chief disadvantage of cellulose nitrate is: a. it yellows b. it is very soft c. it is flammable d. it is expensive	I
3. The discovery of Phenol-formaldehyde the second step forward for the industry. a. in 1909 by Dr. Leo H. Baekeland	The second major step forward for the plastics industry came with the invention of: a. cellulose nitrate b. cellulose acetate c. casein d. phenol-formaldehyde	I
b. was developed through a search for synthetic shellac.	Phenol-formaldehyde was developed as a: a. substitute for shellac b. substitute for ivory c. substitute for paint d. substitute for resin glue	I

OBJECTIVES	TEST ITEMS	EVALUATION				
c. he developed methods for processing it. d. he patented the name Bakelite for it.	BAKELITE is the trade name for a plastics material developed by: a. John Hyatt b. Leo Baekeland c. Adolph Spitteler d. Eric Paulson	I				
e. it is a hard stable, dark plastic material which would turn yellow with age if it was bleached to a light color.	Phenolics are usually dark in color because: a. they cannot be made light b. they gradually get darker c. they are used for dark colored products d. they yellow with age if they are made light	I				
f. Common use -- telephone handset, iron handle	Two common phenolic plastic products many of us have in our home today are: a. telephone handset and electric iron handle b. plastic dishpan and wastebasket c. plastic detergent bottles and soft toys d. plastic refrigerator liners and clock cases	I				
4. Plastics development between 1909 and World War II a. discovery of cold molded plastics	Of the following four plastics, which was not discovered between 1909 and World War II? a. cold molded b. casein plastics c. cellulose acetate d. epoxy resins	II				

OBJECTIVES	TEST ITEMS	EVALUATION				
b. casein plastics from cows milk by A. Spitteler	Casein plastics are made from: a. coal b. oil c. cows milk d. soy beans	I				
c. cellulose acetate, 1927, replaced cellulose nitrate, became first injection molded plastic in 1929, but was a fire hazard d. introduction of polyvinyl chloride, the first of the vinyl family in 1927 e. polystyrene came to U.S.A. in 1938, but was first isolated as early as 1831, became a high volume plastic, cheap.	Two plastics materials were introduced to the U.S.A. in 1927, they were: a. cellulose acetate and polyvinyl chloride b. silicone and casein c. polyethylene and polystyrene d. fluorocarbons and epoxies	I				
5. During World War II a. polyethylene and polyesters in 1942 1) PE -- flexible electrical insulation, made television and radar possible	Which of the following plastics made television and radar possible: a. polyester b. polyethylene c. polystyrene d. polyether	I				
2) polyester -- combined with glass fibers to make reinforced plastics (fiberglass) b. developed because of need for substitutes did to material shortage of World War II	Which one of the following plastics made fiberglass reinforced plastics possible: a. celluloid b. casein c. silicone d. polyester	I				

OBJECTIVES	TEST ITEMS	EVALUATION				
6. After World War II a. slump in use of plastics to 1950	From World War II to 1950 the use of plastics: a. increased b. slumped c. stayed the same d. rose drastically	I				
b. great use after 1950 c. many new plastics materials and processes developed in this period	From 1950 to the present, plastics materials, products, and use have: a. increased drastically b. slumped c. stayed the same d. increased slightly	I				
B. Growth, importance and future of plastics industry a. growth curve low from 1942 to 1952 b. good growth 1942 to 1952 c. rapid growth 1952 to 1962 d. fantastic rate of growth 1962 on	In terms of growth per 20 year periods, the plastics industry grew at the highest rate between the years: a. 1902 to 1922 b. 1922 to 1942 c. 1942 to 1952 d. 1952 to 1962	II				
e. consumption of plastics materials reached 10 billion pounds per year in 1964-1965 = 11.3 billion pounds	In 1964 consumption of plastics materials has surpassed the rate of: a. 5 billion pounds per year b. 7.5 billion pounds per year c. 10 billion pounds per year d. 20 billion pounds per year	I				
f. plastics industry says it has only reached 3%-4% of its total potential	The plastics industry states that today it has reached approximately: a. 3 to 4% of its total potential b. 10 to 15% of its total potential c. 20 to 25% of its total potential d. 30 to 40% of its total potential	I				

OBJECTIVES	TEST ITEMS	EVALUATION				
g. plastics are rapidly replacing several materials, such as metal, glass and ceramics, which were used to produce commercial products h. unlimited new materials, applications and processes are possible	Recently plastics have been replacing a number of materials for commercial fabrication of all kinds of products and containers. The most important three of them are: a. wax, glass and wood b. metal, glass and ceramics c. ivory, shellac and rubber d. ceramics, shellac and wax	I				
C. Organization of the plastics industry 1. plastics materials manufacturers a. manufacture the basic plastics chemicals	Plastics companies which produce basic plastics chemicals for use by the industry are called: a. plastics materials manufacturers b. fabricators and finishers c. processors d. none of these	I				
2. Processor a. produce plastics parts and shapes by one or all of the several basic processes 1) molding (compression, injection, etc.) 2) extruding 3) film and sheeting processes 4) lamination 5) reinforced plastics 6) coating	Plastics companies which manufacture basic plastics parts and shapes are called: a. plastics materials manufacturers b. fabricators and finishers c. processors d. none of these	I				

OBJECTIVES	TEST ITEMS	EVALUATION				
3. Fabricator and Finisher a. work with basic shapes and parts produced by the processors and produce plastics products 1) vacuum forming flat sheet 2) rainware, inflatables, upholstry, etc. from film and sheeting (blown and extruded) 3) plating	Plastics companies which take the basic parts and shapes and produce plastics products from them are called: a. plastics materials manufacturers b. fabricators and finishers c. processors d. none of these	I				
	If you were going to manufacture a product containing injection molded parts which of the following types of plastics manufacturers would you buy these injection molded parts from? a. a plastics materials manufacturer b. a fabricator and finisher c. a processor d. none of these	II				

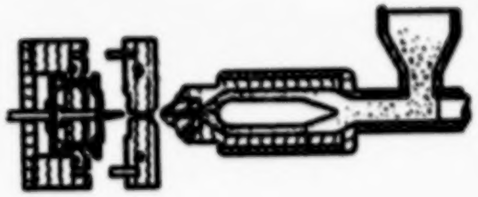
OBJECTIVES	TEST ITEMS	EVALUATION LEVEL	GOOD ITEM	REVISE IT	THROW IT OUT	DOES IT MEASURE LEVEL INDICATED
UNIT II. Introduction to Plastics Materials Upon completion of this unit the student will be able to identify the following material on a multiple choice test.						
A. Definition of plastics 1. a family of synthetic organic materials which have large molecules which are made up of chains of atoms. They are heavy in molecular weight, solid in finished state and can be shaped by flow at some stage of their manufacture. This excludes wax or clay which may also be soft.	Plastics is a family of synthetic organic material made up of: a. heavy atoms b. large molecules c. small molecules d. light atoms	I				
	Wax and clay are: a. included in the definition of plastics b. excluded from the definition of plastics c. both organic materials d. all of the above are correct	I				
B. Classification of plastics 1. thermoplastics -- those plastics materials which are soft when hot and hard when cold and which can be repeatedly resoftened and rehardened. Can be reshaped many times. May be likened to water and ice. A physical change takes place.	Plastics which are soft when hot and hard when cooled are called: a. thermosetting plastics b. thermo-curing plastics c. thermoplastics d. cold molded plastics	I				

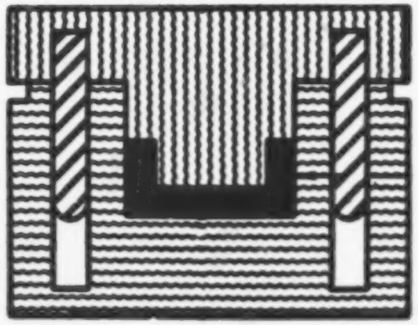
OBJECTIVES	TEST ITEMS	EVALUATION
Continued from B. on previous page.	When candle wax is heated until it melts and then cooled it acts like: a. a thermoplastic b. a thermosetting plastic c. neither of the above d. both of the above	II
	When aluminum is heated until it melts and is then cooled it acts like: a. a thermosetting plastic b. a thermoplastic c. neither of the above d. both of the above	II
	What type of a change takes place in a thermoplastic when heated and cooled: a. chemical b. physical c. electrical d. positive	I
2. Thermosetting plastics -- those plastics materials which are set, cured or hardened into permanent shape by heat and cannot be reshaped or softened by reheating. A chemical change takes place.	Plastics which cure into permanent shape with heat are called: a. thermo curing plastics b. thermosetting plastics c. thermoplastics d. hot molded plastics	I
	When a cake is baked it acts similar to the change which heat makes on: a. thermoplastics b. thermosetting plastics c. thermofusion d. thermoforming	II

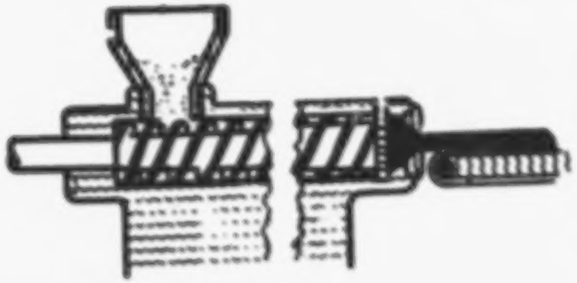
OBJECTIVES	TEST ITEMS	EVALUATION
Continued from 2. on previous page.	What type of a change takes place during the final processing of a thermosetting plastic: a. chemical b. physical c. electrical d. negative	I
C. Plastics Structure 1. Thermoplastic -- chain like valence bonds	The molecular structure of a thermoplastic is in the form of: a. large round atomic orbits b. small atomic orbits c. chain like valence bonds d. cross linking valence bonds	I
2. Thermosetting -- chain like plus cross linking valence bonds	The molecular structure of cured thermosetting plastics is in the form of: a. large round atomic orbits b. small atomic orbits c. chain like valence bonds d. cross linked valence bonds	I
D. Generic names of plastics in general use and their common uses: 1. Thermoplastics a. acrylics -- signs, lenses, etc.- transparent b. cellulosics -- toys, ball pens, color phones - tough, eye glass frames c. nylon -- fabrics, pump impellers, bearings -- strong, self lubricating d. polyethylene -- protective sheeting, film, TV and radar insulation, toys, housewares -- flexible, tough, waxy	Which of the following common plastics is not a thermoplastic: a. acrylic b. cellulosics c. nylon d. phenolic A tough, pliable, waxy thermoplastics material which is used for protective sheeting and housewares is: a. epoxy b. polystyrene c. polyethylene d. polypropylene	II I

OBJECTIVES	TEST ITEMS	EVALUATION
Continued from D1. on previous page. e. polystyrene--brush bristles, insulators, low temp, electrical parts--low cost, low temp properties f. polyfluorocarbons--gaskets, bearings, coatings (teflon)--non adhesive, low friction g. vinyls--rain coats, seat covers, gaskets, foams--flexible, wear resistant h. ABS--pipe, luggage, shoes, trays--hard, low temp flexibility i. acetal--auto instrument panel parts--rigid but not brittle j. polypropylene--electric coffee parts, cameras, film--light, tough k. polycarbonates--high strength parts, electrical parts, etc.--high important strength	A hard thermo-plastics material which remains quite flexible at low temperature is: a. polyesters b. epoxy c. acrylic d. ABS	I
	A tough low friction thermoplastic which is used to coat the inside of frying pans and other kitchen utensils: a. vinyl b. polyfluorocarbons c. nylon d. polycarbonates	I
	A strong self lubricating plastics material used for fabrics: a. vinyls b. acetal c. nylon d. cellulosics	I
	A transparent thermoplastic which is used for signs and tail light lenses is: a. acrylic b. cellulosic c. nylon d. ABS	I
2. Thermosetting plastics a. epoxy--high strength glues, coatings--high strength b. casein--buttons and novelties, glue component	Which of the following common plastics is not a thermosetting plastic? a. melamine b. polyester c. ABS d. epoxies	II

OBJECTIVES	TEST ITEMS	EVALUATION
Continued from D2. on previous page c. cold molded--electrical parts, etc. --water, oil, solvent and heat resistance d. alkyds --electrical parts, paints, enamels--good electrical, weather and chemical resistance e. allylic--electronic parts--high electrical, moisture, and weather resistance f. melamine--dinnerware, counter tops auto ignition--strong tough g. phenolic--iron handles, appliance bases, phones, pot handles--heat and electrical insulator, strong, hard to scratch h. polyester--reinforced plastics--strong chemical resistant i. silicone--waxes, greases, electrical insulation, release agents--high and low temperature stability, low friction j. urea--similar to melamine k. polyurethane--insulation, cushioning, padding, etc.--flexible, foams like foam rubber	A strong, tough thermosetting plastics material used for counter tops and plastic dinnerware: a. urea b. melamine c. phenolic d. vinyl	I
	A strong, dark colored, hard to scratch thermosetting plastics material with good electrical insulation properties which is often used for electric iron handles and appliance bases: a. polyurethane b. silicone c. epoxy d. phenolic	I
	A strong, low cost, chemically resistant thermosetting plastics material which is often used in reinforced plastics: a. polystyrene b. polyester c. urea d. melamine	I
	A high strength, high adhesion thermosetting plastics material used for glues and coatings is: a. casein b. polyester c. polyurethane d. epoxy	I

OBJECTIVES	TEST ITEMS	EVALUATION				
Continued from D2. on previous pages	A thermosetting plastics material which is similar to melamine: a. polyurethene b. polyester c. allylics d. urea	I				
E. Outline of plastics processes 1. injection molding--squeezing or forcing a heated fluid thermoplastic material into a cooled cavity mold	The squeezing of a hot thermoplastic material into a closed cooled mold cavity through a small opening is called: a. compression molding b. extrusion molding c. injection molding d. welding	I				
	Which plastics process is represented by the following diagram?  a. compression molding b. injection molding c. heat sealing d. thermoforming	II				

OBJECTIVES	TEST ITEMS	EVALUATION
2. Compression molding--pressing a thermosetting plastics material in a hot mold until cured.	The pressing of a powdered thermosetting plastics material into a hot mold cavity is called: a. extrusion b. injection c. welding d. compression	I
3. Transfer molding--pressing a thermosetting plastics material from a chamber adjacent to the mold into the mold and curing under heat and pressure.	Which plastics process is represented by the following diagram:  a. compression b. injection c. heat sealing d. thermoforming	II
4. Extrusion molding--continuously pushing a fluid thermoplastic material through a die to form a continuous plastic shape such as a garden hose.	A continuous pressing of a thermoplastic material through a die to form a continuous plastic part is called: a. injection molding b. compression molding c. thermoforming d. extrusion molding	I

OBJECTIVES	TEST ITEMS	EVALUATION				
Continued E4. from previous page.	Which plastics process is represented by the following diagram:  a. heat sealing b. blow molding c. extrusion d. thermosealing	II				
5. Blow molding--putting a soft thermoplastic tube like parison into a mold which is then closed around it and air pressure inserted to force it against the mold walls	Pushing a soft thermoplastic parison into a mold and using air pressure to form it against the mold: a. injection molding b. thermoforming c. blow molding d. thermofusion	II				

OBJECTIVES

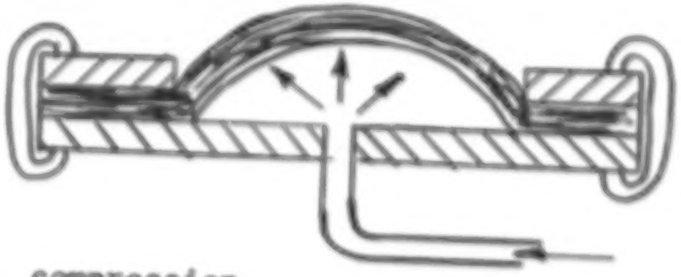
6. Thermoforming -- the heating and stretching to shape a thermoplastic sheet by one of the following methods.
   - a. vacuum
   - b. blow
   - c. stretch

TEST ITEMS

The heating and stretching to shape a thermoplastic sheet material is called:

a. compression molding
b. thermoforming
c. injection molding
d. heat sealing

Which plastics process is represented by the following diagram:

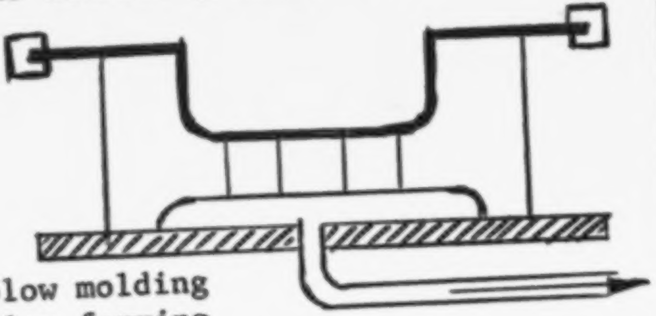


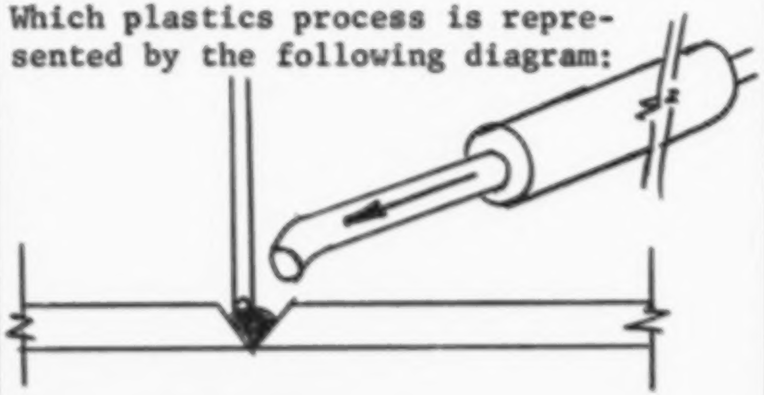
a. compression
b. injection
c. heat sealing
d. thermoforming

EVALUATION

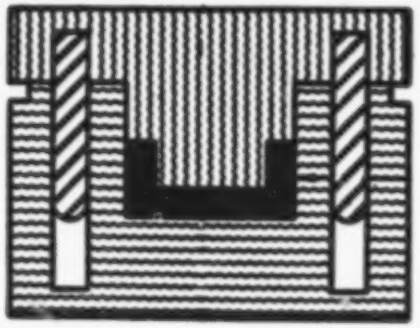
I

II

OBJECTIVES	TEST ITEMS	EVALUATION				
	Which plastics process is represented by the following diagram:  a. blow molding b. blow forming c. mechanical forming d. vacuum forming	II				
7. Calendering -- forming of plastic sheet or film between rolls. 8. Coating--spreading plastics materials over other materials to form coatings. 9. Laminating--pressing layers of plastics materials with other materials to form tough flat sheets. 10. Reinforcing--combining plastics resins with other materials such as glass fibers to form a product.	Forming plastic sheet or film between rollers: a. coating b. calendering c. larminating d. reinforcing	I				

OBJECTIVES	TEST ITEMS	EVALUATION
11. Welding--joining to pieces of thick thermoplastic sheet material by heat and thermoplastic rod.	The joining of two pieces of thick thermoplastic sheet material by heat and a plastic rod is called: a. heat sealing b. welding c. thermofusion d. thermoforming	I
	Which plastics process is represented by the following diagram:  a. heat sealing b. welding c. thermofusion d. thermoforming	II

OBJECTIVES	TEST ITEMS	EVALUATION				
12. Heat sealing -- joining of two thin pieces of thermoplastics film material together by heat and pressure.	The joining of two thin pieces of thermoplastic film by heat and pressure is called: a. heat sealing b. welding c. thermofusion d. thermoforming	I				
UNIT III. Practical application of plastics processes and materials. Upon completion of this unit the student should be able to identify the following facts, understand the interrelationships of these facts and abstractions learned in this unit and the two preceding, and apply these understandings and facts to practical situations similar to those in which they were learned.		Level	Good Item	Revise it	Throw it out	Does it measure level indicated?
A. Compression molding -- material is compressed in a hot mold a. preheating -- mold and material, mold 300° F to 400° F b. loading or charging mold -- measured amount c. partial mold closing -- breathing d. full closing -- flow and cure e. opening -- ejection	Compression molding of thermosetting materials is comprised of a. two stages b. three stages c. four stages d. five stages	I				
	Commonly used molding temperatures for compression molding of thermosetting compounds are: a. 200-300° F b. 250-350° F c. 300-400° F d. 400-500° F	I				

OBJECTIVES	TEST ITEMS	EVALUATION				
Continued from A., 1. on page 16.	In order to complete the compression molding cycle the mold must be: a. cooled then heated b. cooled c. heated then cooled d. heated	II				
	In order to complete the curing of a thermosetting material in this mold one must:  a. add more material b. add heat c. add more pressure d. cool the mold	II				
2. Equipment needed: a. matched die mold b. mold heating device c. method of exerting force on mold	Which of the following is not a part of the equipment needed for compression molding of thermosetting compounds: a. mold chiller b. matched mold c. heating device d. method of exerting force on the mold	II				

OBJECTIVES	TEST ITEMS	EVALUATION			
3. Types of molds a. fully positive mold b. semi-positive mold c. landed positive mold c. flash mold	Which of the following is not a mold type used for compression molding of thermosetting compounds: a. fully positive mold b. contact mold c. semi-positive mold d. flash mold	II			
	A compression mold which will not allow excess material to escape during compression is called: a. fully positive mold b. flash mold c. semi-positive mold d. landed positive mold	II			
4. Parts of the mold a. main parts 1) force (plunger) 2) cavity b. auxiliary parts 1) guide pins 2) ejection pins	The two halves of a simple compression mold are called: a. force and cavity b. drag and force c. drag and cavity d. force and platen	I			
5. Materials common used -- thermosetting a. phenolic b. urea c. melamine d. alkyds e. polyesters f. epoxies	From the following list select the material which is not a common thermosetting material: a. phenolic b. urea c. casein d. melamine	II			

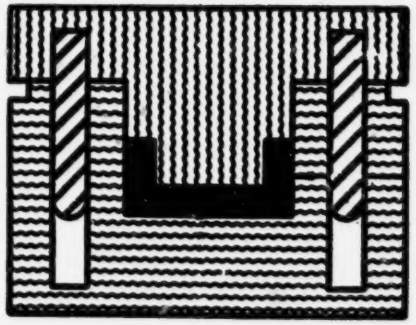
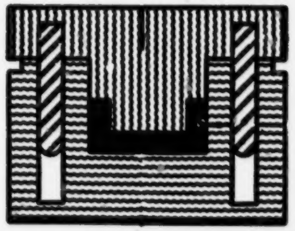
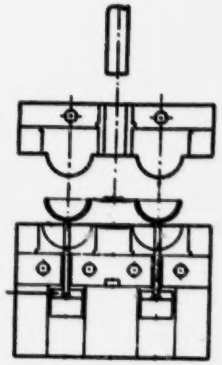
OBJECTIVES	TEST ITEMS	EVALUATION				
6. Parts of a compression molding press a. platens 1) stationary 2) movable	The two parts of a compression molding press onto which the mold halves are directly connected are called: a. platens b. rams c. columns d. covaties	I				
b. ram 1) usually vertical movement 2) applies pressure to movable platen, usually lower one	The ram of a compression molding press is directly connected to the: a. stationary platen b. covaties c. fully positive molds d. movable platen	I				
c. columns 1) often allow adjustment of daylight 2) hold platens in alignment	The vertical structural members of a compression molding press are called: a. platens b. columns c. covaties d. rams	I				
7. Capacity of the press -- total tons of force which can be applied to the mold.	The capacity of a compression molding press is given as: a. the total tons of force applied to the mold b. the daylight opening of the press c. the weight of the material held in the mold d. the maximum stroke length of the press	I				

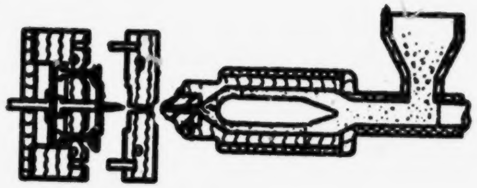
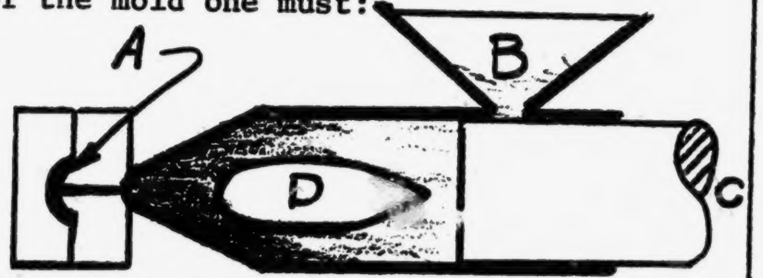
OBJECTIVES	TEST ITEMS	EVALUATION
8. Materials for compression and transfer molding all thermosetting materials. Some not well adapted to transfer. Come in either dry powder or pellet or liquid form. Powder and pellets may be preformed into compact disc. 1) Basic plastic materials a. alkyds b. melamine c. urea d. phenolics e. also molding of polyester as epoxy and reinforcing materials for FRP or RP 2) Other materials a. fillers -- glass fibers, asbestos, wood flower, thread, canvas, etc. increase bulk and reduce cost but cut flow. b. plasticizers -- increase flow, change character of finished product c. pigments -- add color d. lubricants -- for flow and easy release	Materials used to increase the bulk factor and reduce the cost in compression molding compounds are called: a. reinforcers b. fillers c. plasticizers d. pigments When materials which increase the bulk factor are added to a phenolic compound what must be added to offset the reduced flow: a. fillers b. pigments c. plasticizers d. preforms	I II
3) Stages of material a. powder, pellet or preform (loaded) b. fluid or flow stage (under heat and pressure) c. cured state (after chemical change)	The middle stage in the molding of a compression molding compound is: a. flow stage b. preform stage c. pellet stage d. cure stage	II

OBJECTIVES	TEST ITEMS	EVALUATION
Continuation of 8., 3) from page 20.	How can a melamine, urea or phenolic compound be condensed to decrease the bulk factor and fit it into the mold better: a. cure it b. add fillers c. weigh it properly d. preform it	II
9. Operation 1) Set up the mold in press 2) Heat the mold 3) Measure the plastic charge 4) Preheat the charge (often not necessary for small parts) 5) Apply mold release to mold 6) Open the mold 7) Charge the mold 8) Close the mold -- bring pressure up until you feel the material flow. Pressure gauge will drop as the material flows* 9) Breathe the mold 10) Allow to cure (try 3 minutes at 300 F for phenolics) 11) Open the mold and eject the part *Pressure necessary 2000 PSI** - phenolic 3000 PSI - urea 4000 PSI - melamine **PSI figures as pounds per square inch of surface of the part.	How much total force is necessary when compression molding phenolic molding compounds with a surface area of two square inches? a. 2500 pounds b. 4000 pounds c. 6000 pounds d. 8000 pounds	III
	Why is it necessary to open the mold slightly after closing it on the charge of material when compression molding? a. to assure proper mold alignment b. to allow the heat to adjust properly c. to make sure the pressure gauge is working properly d. to allow gasses to escape	II
	When the pressure gauge drops suddenly as you are building up the pressure on a compression molding charge you know: a. the charge is too small b. the mold is too hot c. the material is flowing d. the gasses have escaped	II

OBJECTIVES	TEST ITEMS	EVALUATION
Continued from 9. Operation on previous page.	If the molding surface size is increased in compression molding: a. the total clamping pressure needed is decreased b. the heat required for cure is increased c. the total clamping pressure needed is increased d. the heat required for cure is decreased	II
B. Transfer molding--material is transfered. A compression molding type process which resembles injection molding. Material is loaded into a chamber usually located above and connected to the mold cavities. A cull which must be thrown away results from the transfer chamber and sprew.	In transfer molding the plastics compound is loaded into what part of the press for processing: a. sprue b. mold c. transfer chamber d. transfer plunger	I
	Transfer molding is similar to which of the following molding methods: a. blow forming b. thermoforming c. extrusion molding d. compression molding	II

④

OBJECTIVES	TEST ITEMS	EVALUATION
Continued from B. on previous page.	Which type of plastic material would be used in the mold diagrammed here? a. thermoplastic b. thermofusion c. thermoforming d. thermosetting 	II
1. Advantages--material flows around inserts and pins without distorting them, delicate sections 2. Disadvantages--more clamping pressure required on mold, higher molding pressures required, limits the use of some fillers as they reduce flow.	Of the two diagrammed processes:  A  B a. A requires more molding pressure b. B requires more molding pressure c. Both require the same molding pressure d. One cannot determine which requires the greatest molding pressure	II

OBJECTIVES	TEST ITEMS	EVALUATION				
C. Injection molding--material is heated then squeezed into a cool mold under pressure similar to transfer molding of thermosets, similar to die casting of metals--screw or plunger device for forcing it in.	If thermosetting plastics were forced into a mold by a continuous screw device the process would be called: a. compression molding b. injection molding c. extrusion d. transfer molding	II				
1. Steps in injection molding a. material placed in hopper b. material forced into heating cylinder c. melted material forced into closed mold d. material cools in mold e. mold opened and part removed	Which plastic material would be used in the process diagrammed here:  a. phenolic b. melamine c. urea d. polystyrene	II				
	In order to get material into cavity A of the mold one must:  a. apply heat at point A b. apply pressure at point D c. apply heat at point B d. apply pressure at point C	II				

OBJECTIVES	TEST ITEMS	EVALUATION				
Continued from C., 1., on page 24.	Injection molding is a plastics molding process which is most similar to which of the following metal processes: a. green sand casting b. die casting (hot chamber) c. sheet forming d. shell molding	III				
	Injection molding is a plastics molding process which is similar to which of the following plastics processes: a. mechanical stretch forming b. vacuum forming c. heat sealing d. transfer molding	III				
	Each time material is injected into a mold in injection molding the plastic material: a. adds heat to the mold b. cools the mold c. has to be removed before it cools d. has to be cut from the sprue before removed	II				
	Water is run through an injection mold in order to: a. cool it b. heat it c. lubricate it d. keep it from sticking	II				

OBJECTIVES	TEST ITEMS	EVALUATION
2. Parts of the press a. Injection unit 1. hopper 2. heating cylinder 3. ram or plunger 4. nozzle 5. torpedo b. Mold clamp device 1. ram 2. platens 3. columns	The torpedo of an injection molder is that part which: a. heats the plastic pellets b. connects the injection unit to the mold c. spreads the plastic material in the heating cylinder d. pushes the plastic material forward in the heating cylinder	I
	If you had a plastics machine with the following parts 1) a torpedo 2) heating bands and 3) a hopper you would have: a. a compression molder b. an injection molder c. an extruder d. a thermoformer	II
	An injection molder is divided into two general parts. They are: a. platens and ram b. columns and hopper c. heating and cooling areas d. injection unit and mold clamp device	II
3. Size of the press -- specified in terms of maximum number of ounces of cellulose acetate that can be injected in one shot, 1/5 to 300 ounces.	The size of an injection molder is given as: a. the clamp force in tons of the press b. the maximum stroke length of the press c. the maximum number of ounces of cellulose acetate injected in one shot d. the weight of the material held by the heating cylinder	I

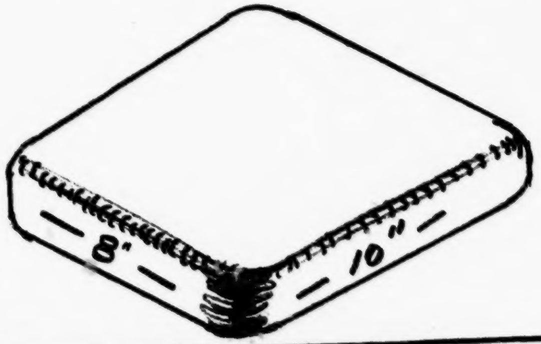
OBJECTIVES	TEST ITEMS	EVALUATION
Continued from 3. on page 26.	A 300 ounce injection molding machine would be: a. a large machine b. a small machine c. a laboratory sized machine d. too large to be practical	II
4. Parts of the mold a. Cavity b. Sprue c. Runner d. Gate e. Cold slug well f. Vents g. Ejection devices	Because the gate is smaller than the sprue it holds back against the plastic material and it will a. increase the pressure applied to the mold surface b. regulate the size of the runner c. regulate the size of the sprue d. decrease the pressure applied to the mold surface	III
	If the gate into a mold cavity is increased in size the pressure necessary to force the material into the mold will: a. increase b. decrease c. stay the same d. none of these	II
	If the gate into a mold cavity is decreased in size with the same pressure: a. the material will flow faster at that point b. the material will flow slower at that point c. the material will retain the heat longer d. the material will fill the mold easier	II

OBJECTIVES	TEST ITEMS	EVALUATION				
Continued from 4. on previous page.	In injection molding of thermoplastics three parts carry the material to the cavity. Which of the following is closest to the nozzle of the molder: a. sprue b. runner c. gate d. hopper	II				
	Several parts formed in one injection mold are connected by: a. runners b. sprews c. gates d. cavities	II				
5. Operation of the injection molder. a. set up the press--heat up press b. load hopper--keep pellets clean and dry c. ram some pellets into cylinder d. let plastic in cylinder soak up heat 1) material becomes semi-fluid 2) too hot to touch 3) purge nozzle e. place mold in press and clamp (100° to 120° F)	In order for the plunger to push material forward in the cylinder in injection molding: a. the mold must be closed b. the mold must be open c. material must first be placed in the hopper d. force must be applied to the platens	II				
	In order for the plastic material to move through the injection molder nozzle: a. it must be heated b. the mold must be open c. the mold must be closed d. the mold must be heated	II				

OBJECTIVES	TEST ITEMS	EVALUATION
Continued from 5. on previous page f. inject the plastic into the mold 1) pressure approximately 5,000 to 40,000 PSI 2) hold pressure on material for a few seconds after mold fills to assure complete fill and cooling time	The mold in injection molding is usually between a. 40° and 60° F b. 60° and 80° F c. 80° and 100° F d. 100° and 120° F	I
g. release injection pressure h. unclamp and remove mold i. remove or eject part j. inspection	The nozzle pressure in injection molding is approximately: a. 4,000 to 8,000 PSI b. 8,000 to 12,000 PSI c. 5,000 to 40,000 PSI d. 15,000 to 20,000 PSI	I
1) sinking--not enough pressure, pressure not hold, material too hot 2) over packing--too much initial pressure, object loses shape when removed 3) short shot--too little pressure, material not hot enough, plugged nozzle 4) flashing--too much pressure, too little clamp pressure, material too hot	In order to assure a complete injection molded part one must: a. keep the mold warm enough to prevent cooling too rapidly b. hold the pressure on the injected material a few seconds after filling the mold c. allow the mold to breath after injection d. purge the nozzle frequently	II
	After ejection from an injection mold the part is cut from its: a. gate b. sprue c. sprue and runners d. nozzle	II

OBJECTIVES	TEST ITEMS	EVALUATION
Continued from 5. on previous pages	In injection molding the platens must hold the mold closed because: a. the material expands in the mold as it cools b. the pressure applied to the plastics material tends to force the molds apart c. the nozzle would leak otherwise d. the material must be compressed in the mold	II
	In injection molding one product of a complete molding cycle is called: a. family b. shot c. gate d. part	I
	A short shot in injection molding is one that: a. does not require much material b. has a short sprew c. has a short runner d. does not fill properly	II
	It is called flashing in injection molding when the: a. material catches fire b. material goes beyond the parting line c. nozzle leaks d. material is too cool for injection	II

OBJECTIVES	TEST ITEMS	EVALUATION
6. Materials used for injection molding. Most all thermoplastic, especially a. acrylics b. polystyrene c. polyethylene d. polypropylene e. cellulosics f. ABS	From the following list which material probably would not be injection molded: a. polyethylene b. melamine c. acrylic d. ABS	II
7. Advantages a. cheaper and faster than compression b. many parts molded in one "shot" c. low material cost compared to sheet stock 8. Use a. high volume, low cost items 9. Changing materials or colors a. purge the cylinder	Purging the cylinder on an injection molder is necessary to: a. keep it from leaking b. check the material temperature c. change materials or colors d. check material colors	II
D. Thermoforming--a method of shaping sheet plastics over a mold 1. Stages a. clamping the sheet b. heating the sheet (275° to 400° F) c. forming the sheet d. cooling the sheet	Most plastics sheets soften sufficiently for thermoforming between what temperatures: a. 175° to 300° F b. 275° to 400° F c. 375° to 500° F d. 475° to 600° F	I
2. Equipment needed a. heating unit of oven b. clamping device to hold plastic c. mold to shape plastic on d. source of vacuum, pressure or mechanical force to push plastic into place or mold	There are four stages in the thermoforming process. Before heating the plastic sheet one must: a. form the sheet b. clamp the sheet c. cool the sheet d. none of these	II

OBJECTIVES	TEST ITEMS	EVALUATION
Continued from D. 2. on page 31.	You are asked to design and mold or form an inexpensive cover for a small beverage cooler (6" by 10"). No insulation factor need be figured. The production run will be 25 units. Which combination of materials and process would be most economical? a. compression molded phenolic b. injection molded polyethylene c. thermoformed polystyrene d. extruded polypropylene  	III
3. Scientific principles a. vacuum forming -- remove air one side, atmospheric pressure on other side b. blow forming -- air pressure applied to one side c. mechanical forming -- mechanical pressure applied d. heat effect -- heat effect causes molecular band to loosen	In vacuum forming of thermoplastics pressure applied to the plastic sheet is: a. greater than that of the atmosphere b. less than that of the atmosphere c. the same as the atmosphere d. none of these Allowing the molecular band in plastics to slip will: a. destroy the plastics material b. produce a formable material c. make the plastics material harder d. produce a chemical change in the material	I I

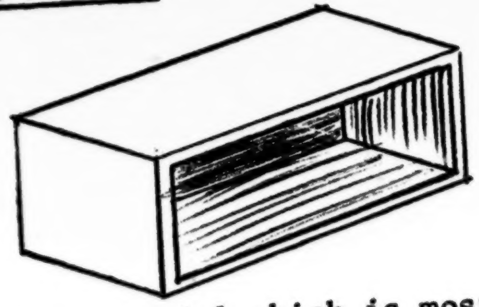
OBJECTIVES	TEST ITEMS	EVALUATION
Continued from 3. on previous page.	A process, called skin packaging, where a thin plastic film is drawn down over a hard goods item like a tool is a variation of: a. thermofusion b. window packaging c. vacuum forming d. blow packaging	II
4. Types of forming a. vacuum--most common use, drape and cavity molds--refrigerator door liners, bubble packages, skin packaging, etc. b. blow--deep draws, thicker sheet, sharper details--free and controlled blow c. mechanical--very deep draws, simple shapes, hard to form materials--assist for other two processes	Which of the following methods would you choose to thermoform a part which requires fine details to be on the outside surface: a. vacuum cavity forming b. vacuum drape forming c. free blowing d. mechanical stretch forming	
	One of the following is not a thermoforming device, which is it: a. mechanical former b. thermofusion former c. vacuum former d. blow former	II
	A plastics process which utilizes the formability of plastic sheet is called: a. thermofusion b. thermoplastics c. thermosetting d. thermoforming	I
	The most common thermoforming method is: a. mechanical forming b. vacuum forming c. blow forming d. thermofusion forming	I

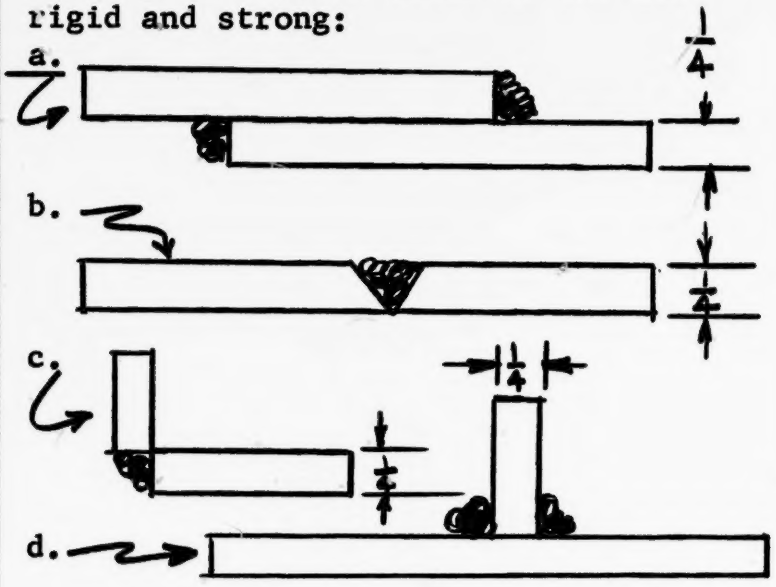
OBJECTIVES	TEST ITEMS	EVALUATION			
Continued from 4. on page 33.	Vacuum forming of thermoplastic sheet where the sheet is drawn into the mold, the mold is called a: a. cavity mold b. drape mold c. inside mold d. contact mold	II			
	Vacuum forming of thermoplastic sheet where the sheet is drawn over a mold is called: a. cavity molding b. drape molding c. inside molding d. contact molding	II			
	Which of the following methods would you choose to thermoform a plastic bowl in order to eliminate marks on both surfaces of the plastics: a. controlled blowing b. vacuum forming c. free blowing d. mechanical stretch	III			
	Which method would be most successful in thermoforming for a deep draw on a thick, hard-to-form sheet? a. high vacuum forming b. high pressure blow forming c. low pressure mechanical stretch forming d. vacuum forming and mechanical assist	III			

OBJECTIVES	TEST ITEMS	EVALUATION
5. Advantages of thermoforming a. large items can be formed b. equipment is low cost for its size c. molds are easy to make and inexpensive d. ideal for short production runs e. quick to set up production f. changes easy and economical to make	Which of the following items should you manufacture by thermoforming methods: a. telephone handset b. refrigerator door liner c. electric clock housing d. coffee pot base	II
6. Disadvantages a. material costs more than for most other methods b. production slower than injection	If you were designing a full size sports car body to be made of plastic and the production run was expected to be short (5 units) which method would you use for maximum strength and economy: a. injection molding b. compression molding c. thermoforming d. thermofusion	II
	Of the following items which is a disadvantage of thermoforming: a. material costs b. size of item which can be formed c. equipment cost for its size d. mold costs	II

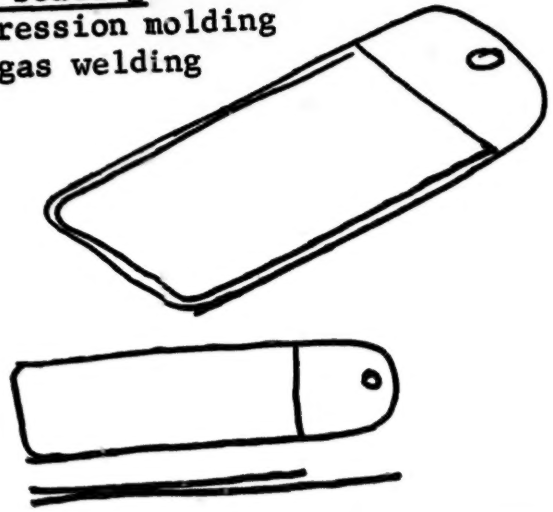
OBJECTIVES	TEST ITEMS	EVALUATION
7. Materials used -- any thermoplastic sheet -- most common are -- extruded less expensive and stretch more easily a. hi-impact polystyrene (preferred, lowest cost, strong, opaque) b. cellulose acetate c. cellulose acetate butyrate d. ABS -- strong, tough, low temperature impact strength e. vinyl -- flexible f. acrylic -- allows light through, strong but brittle at low temperatures	Of the thermoplastic sheet materials used for thermoforming, those made by what method are least expensive and stretch more easily: a. calendered b. casting c. laminating d. extruding	I
	Which of the following materials should be chosen for small low cost, sturdy, opaque sign to vacuum formed: a. hi impact polystyrene sheet b. ABS sheet c. polypropylene sheet d. acrylic sheet	II
	Thermoforming is a plastics forming method which can be used: a. with all plastics materials b. for all thermoplastic sheet materials c. for all thermosetting plastics materials d. for only a few plastics materials	I

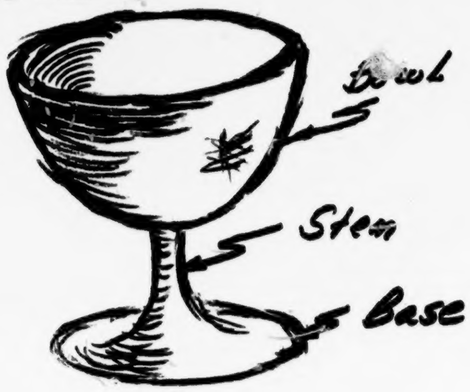
OBJECTIVES	TEST ITEMS	EVALUATION				
Continued from 7. on previous page.	Which of the following materials should be chosen to thermoform a freezer door liner to give maximum impact strength and rigidity, disregarding cost: a. hi impact polystyrene b. acrylic c. ABS d. cellulosic	II				
E. Thermal welding 1. Hot gas welding -- similar to gas welding of metals, but no flame used, just hot air or gas	Hot gas welding of plastics is most similar to: a. arc welding of metals b. gas welding of metals c. heat sealing d. induction welding	III				
	Of the following which would not be a comparison between hot gas welding and heated tool welding: a. one uses heat, the other heat and pressure b. one joins thick materials the other thin materials c. one uses a rod, the other does not d. one uses induction, the other does not	II				

OBJECTIVES	TEST ITEMS	EVALUATION
a. stages 1) heat applied to liquify the surfaces 2) parts are held together and a filler rod inserted in the joint 3) the joined part is cooled b. equipment used 1) air compressor 2) hot gas welder	Which of the following processes should be selected to make five plastic radio equipment cabinets with a uniform 1/4" wall thickness at lowest cost as shown: a. injection molding b. heat sealing c. compression molding d. hot gas welding 	II
c. materials welded -- most thermoplastic sheets can be welded -- thick sheets. Best is PVC (polyvinyl chloride)	The plastics material which is most successfully hot gas welded is: a. acrylic b. allylic c. polyvinyl chloride (PVC) d. ABS	I
d. procedure 1) prepare and secure materials to be welded -- 45° to 60° V grove, root gap 2) connect air supply and turn air on 3) connect electricity and warm up element 4) heat the material and rod at end (40% heat on rod, 60% on material brush air stream over work -- push rod down into joint 5) advance across the material, hold rod at right angle to work	Hot gas welding is used most successfully for: a. thin plastic film b. thick plastic sheet c. thin plastic sheet d. thick plastic film	I

OBJECTIVES	TEST ITEMS	EVALUATION
2. Heat sealing by heated tool a. stages 1) materials placed together 2) heat and pressure applied 250° to 400° melts and fuses the two parts 3) cooling	In hot gas welding of thermoplastics what percentages of heat should be applied to the hod and material: a. 60% to rod and 40% to material b. 50% to rod and 50% to material c. 40% to rod and 60% to material d. 30% to rod and 70% to material	I
	At what angle should the rod be to the material in hot gas welding of thermoplastics material: a. right angles to the work b. slight angle to the rear c. at 45° to the work d. at 30° to the work	I
	Of the following welded thermoplastic sheet joints which would be the most rigid and strong: 	II

OBJECTIVES	TEST ITEMS	EVALUATION
Continued from 2. on page 38.	If in hot gas welding of thermoplastic sheet the percentage of heat applied to the rod is increased the: a. parent materials may become scarred b. rod might break c. rod may not stick d. parent material may warp	II
	In hot gas welding the rod is not melted to a liquid as in gas welding because: a. it will not melt b. it cannot be properly controlled in a molten state c. it will not stick in a molten state d. a welder could not be made to produce enough heat	II
	In heat sealing of thermoplastic materials by heated tool methods the materials are sealed by: a. heat and pressure b. pressure sensitive adhesives c. friction d. heat induction	I
b. equipment used 1) heat sealing iron or machine c. materials to be sealed -- many plastics films 1) polyethylene 2) styrenes 3) vinyls 4) cellulose acetate	In heat sealing of thermoplastic materials with a heated tool: a. all thermoplastic materials may be used b. all thermoplastic materials except cellulose nitrate may be used c. polyethylene, styrenes, vinyls and cellulose acetate may be used d. only cellulose nitrate may be used	I

OBJECTIVES	TEST ITEMS	EVALUATION
Continued from 2. b) and c) on page 39.	Which process should be selected to produce a thin inexpensive, flexible plastic key case as diagrammed: a. injection molding b. heat sealing c. compression molding d. hot gas welding 	II
3. Friction welding -- two identical kinds of plastic are rubbed together with enough speed and pressure to cause heat and fusion	Of the following machines which can be used successfully for friction welding: a. circular saw b. hand drill c. drill press d. band saw	II

OBJECTIVES	TEST ITEMS	EVALUATION				
Continued from 3. on page 40.	From the following list of fastening processes which should be used to join an acrylic plastic bowl to its base (see diagram): a. heated tool heat sealing b. hot gas welding c. friction welding d. mechanical linkage 	III				
4. Induction welding -- heat is induced by a high frequency electrodynamic field in a metallic insert placed in the joint. 5. High frequency heat sealing -- high frequency (radio frequency) energy is passed through the joints by pressured electrodes.	Thermal welding of plastics in which heat is induced by a high frequency electrodynamic field is called: a. high frequency heat sealing b. friction welding c. heated tool sealing d. induction welding	I				

OBJECTIVES	TEST ITEMS	EVALUATION
F. Relationships between materials, processes and products a. From information, facts and principles of operation learned in all three units the student should be able to select some obvious choices of materials, processes and products which, in combination, would produce the desired product or result.	What process and materials should be chosen to mold or form an electrical switch box insulation block with inserts: a. thermoformed polystyrene b. compression molded melomine c. welded PVC sheet d. transfer molded phenolic	II
	Of the following plastics materials which should be chosen for a flame resistant thermoplastic injection molding application: a. cellulose nitrate b. cellulose acetate c. melomine d. alkyd	II
	Thermosetting plastics normally require heat and pressure to cure. If heat were not applied which would result? a. the material would only compact b. the material would flow c. the material would not compact at all d. the material would be damaged	II

OBJECTIVES	TEST ITEMS	EVALUATION				
Continued from F., a. on page 42.	Thermosetting plastics normally require heat and pressure to cure. If pressure were not applied which would result? a. the material would flow but not cure b. the material would flow, but not compact c. the material would compact but not flow d. the material would not cure	II				
	The structure of thermoplastics and thermosetting plastics can be compared by: a. comparing the types of atoms in the molecule b. comparing the structure of the atoms in the molecule c. comparing the way in which the atoms are held together within the molecule d. comparing the number of atoms in the molecule	II				

Appendix B

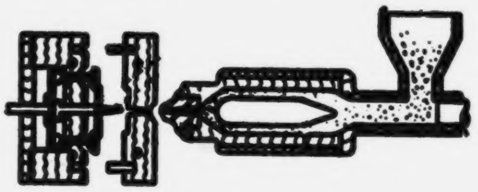
B-1 116 Item Plastics Test

Appendix B-1

Plastics Test

Multiple Choice: Select the best answer for each question and place the number for that answer in the appropriate space on the answer sheet with a #2 lead pencil.

1. Which plastic material would be used in the process diagrammed here?
   1. phenolic
   2. melamine
   3. urea
   4. polystyrene



2. When the pressure gauge drops suddenly as you are building up the pressure on a compression molding charge you know
   1. the charge is too small
   2. the mold is too hot
   3. the material is flowing
   4. the gases have escaped

3. Of the following items which is a disadvantage of thermoforming:
   1. material costs
   2. size of item which can be formed
   3. equipment cost for its size
   4. mold costs

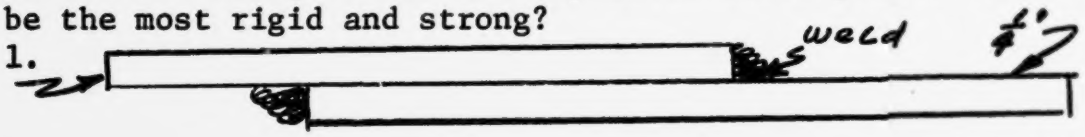
4. In order for the plastic material to move through the injection molder nozzle
   1. the material must be heated
   2. the mold must be open
   3. the mold must be closed
   4. the mold must be heated

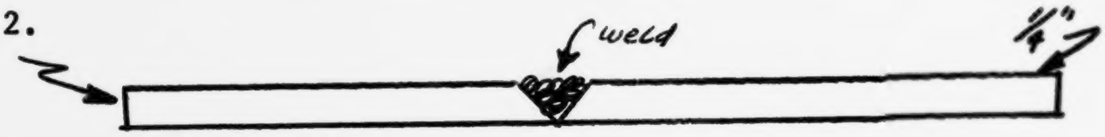
5. Which one of the following items should you manufacture by thermoforming methods?
   1. telephone handset
   2. refrigerator door liner
   3. electric clock housing
   4. coffee pot base

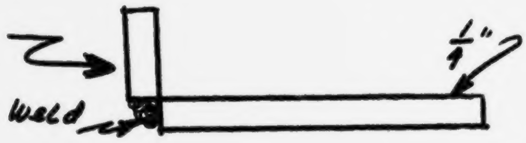
6. When candle wax is heated until it melts and then cooled it acts like:

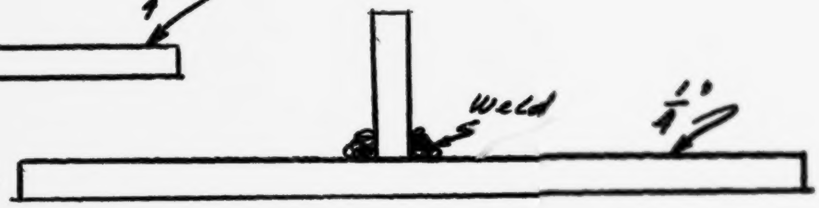
   1. a thermoplastic
   2. a thermosetting plastic
   3. neither of the above
   4. both of the above

7. Of the following welded thermoplastic sheet joints which would be the most rigid and strong?

1.


2.


3.


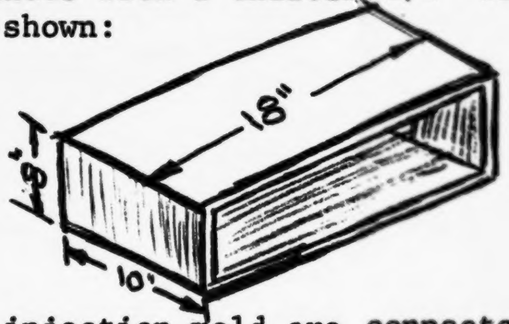
4.


8. The torpedo of an injection molder is that part which
1. cools the plastic pellets.
2. connects the injection unit to the mold.
3. spreads the plastic material in the heating cylinder.
4. pushes the plastic material forward in the heating cylinder.

9. The plastic material which was used for the first flexible photographic films was:
1. shellac
2. cellulose nitrate
3. cellulose acetate
4. phenolic

10. Which of the following processes would be selected to make five plastic radio equipment cabinets with a uniform 1/4" wall thickness at lowest cost as shown:

1. injection molding
2. heat sealing
3. compression molding
4. hot gas welding



11. Several parts formed in one injection mold are connected by:

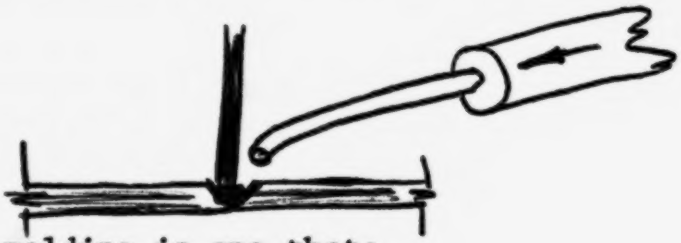
1. runners
2. sprews
3. gates
4. cavities

12. From the following list which material probably would not be injection molded:
1. polythylene
2. melamine
3. acrylic
4. ABS

13. When the percentage of heat applied to the rod is increased in hot gas welding of thermoplastic sheet the:
    1. parent materials may become scarred
    2. rod might break
    3. rod may not stick
    4. parent material may warp

14. Each time material is injected into a mold in injection molding the plastic material:
    1. adds heat to the mold
    2. cools the mold
    3. has to be removed before it cools
    4. has to be cut from the sprew before removed

15. Which plastic process is represented by the following diagram?
    1. heat sealing
    2. welding
    3. thermofusion
    4. thermoforming



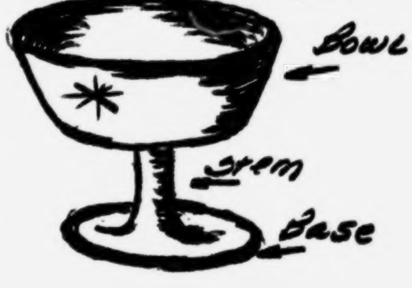
16. A short shot in injection molding is one that:
    1. does not require much material
    2. has a short sprew
    3. has a short runner
    4. does not fill properly

17. The plastics industry states that today it has reached approximately what percent (%) of its potential?
    1. 3 to 4%
    2. 10 to 15%
    3. 20 to 25%
    4. 30 to 40%

18. The structure of thermoplastics and thermosetting plastics can be compared by:
    1. comparing the types of atoms in the molecule
    2. comparing the structure of the atoms in the molecule
    3. comparing the way in which the atoms are held together within the molecule
    4. comparing the number of atoms in the molecule

19. The worlds first commercial plastics material was:
    1. cellulose nitrate
    2. cellulose acetate
    3. phenol-formaldehyde
    4. nylon

20. From the following list of fastening processes which should be used to join an acrylic plastic bowl to its stem? (See diagram)



1. heated tool heat sealing
2. hot gas welding
3. friction welding
4. mechanical linkage

21. Two common phenolic plastic products many of us have in our home today are:
1. telephone handset and electric iron handle
2. dishpan and wastebasket
3. detergent bottles and soft toys
4. refrigerator door liners and food packages

22. The squeezing of a hot thermoplastic material into a closed cooled mold cavity through a small opening is called:
1. compression molding
2. extrusion molding
3. injection molding
4. welding

23. Flashing in injection molding is when the
1. material catches fire
2. material goes beyond the parting line
3. nozzle leaks behind the mold
4. material is too cool for injection

24. What type of a change takes place during the final processing of a thermosetting plastic?
1. chemical
2. physical
3. electrical
4. mechanical

25. Of the following plastics which one was discovered after World War II?
1. celluloid
2. casein plastics
3. cellulose acetate
4. epoxy resins

26. The rated capacity of a compression molding press is usually stated as:
1. the total tons of force applied to the mold
2. the daylight opening of the press
3. the weight of the material held in the mold
4. the maximum stroke length of the press

27. Which of the following methods would you choose to thermoform a plastic bowl in order to eliminate marks on both surfaces of the plastic?
    1. controlled blowing
    2. vacuum forming
    3. free blowing
    4. mechanical stretch

28. In injection molding the platens must hold the mold closed because:
    1. the material expands in the mold as it cools
    2. the pressure applied to the plastics material tends to force the molds apart
    3. the nozzle would leak otherwise
    4. the material must be compressed in the mold

29. Thermal welding of plastics in which heat is induced by a high frequency electrodynamic field is called:
    1. high frequency heat sealing
    2. friction welding
    3. heated tool sealing
    4. induction welding

30. The two parts of a compression molding press onto which the mold halves usually are directly connected are called:
    1. platens
    2. rams
    3. columns
    4. cavities

31. A 300 ounce injection molding machine would be:
    1. a large machine
    2. a small machine
    3. a laboratory sized machine
    4. too large to be practical

32. Which of the following processes and materials should be chosen to mold or form an electrical switch box insulation block with inserts?
    1. thermoformed polystyrene
    2. compression molded melamine
    3. welded PVC sheet
    4. transfer molded phenolic

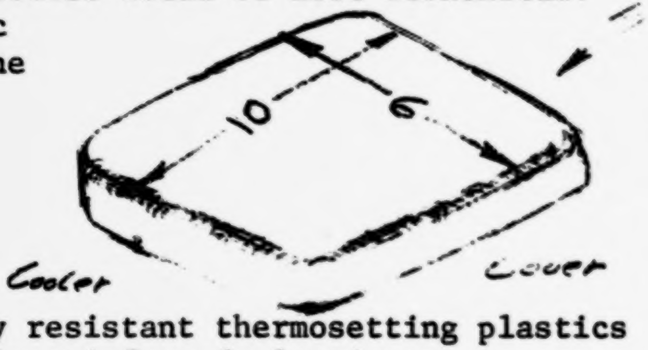
33. In transfer molding the plastics compound is loaded into what part of the press for processing?
    1. sprew
    2. mold
    3. transfer chamber
    4. transfer plunger

34. The size of an injection molder is given as:
    1. the clamp force of the press in tons
    2. the maximum stroke length of the press
    3. the maximum number of ounces of cellulose acetate injected in one shot
    4. the weight of the material held by the heating cylinder

35. Because the gate is smaller than the sprue, it holds back against the plastic material and it will:
    1. increase the pressure applied to the mold surface
    2. regulate the size of the runner
    3. regulate the size of the sprue
    4. decrease the pressure applied to the mold surface

36. Thermosetting plastics normally require heat and pressure to cure. If heat were not applied which would result?
    1. the material would only compact
    2. the material would flow
    3. the material would not compact at all
    4. the material would be damaged

37. You are asked to design and mold or form an inexpensive cover for a small beverage cooler (6" by 10"). No insulation factor need be figured. The production run will be 25 units. Which combination of material and process would be most economical?
    1. compression molded phenolic
    2. injection molded polythylene
    3. thermoformed polystyrene
    4. extruded polypropylene

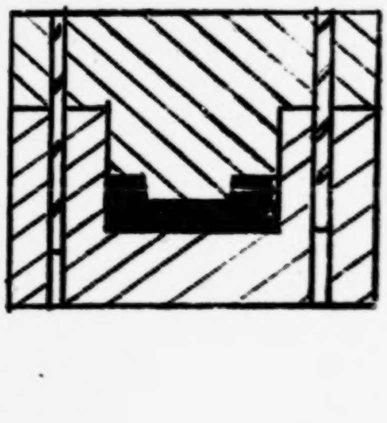


38. A strong, low cost, chemically resistant thermosetting plastics material which is often used in reinforced plastics:

    1. polystyrene
    2. polyester
    3. urea
    4. melamine

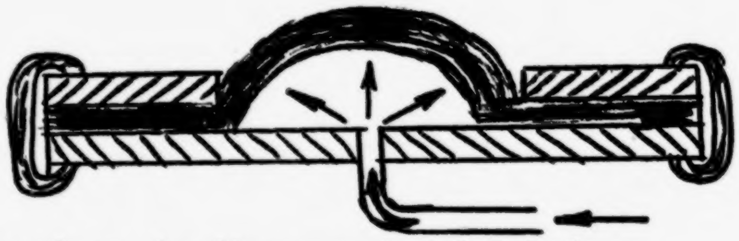
39. Which plastics process is represented by the following diagram?

    1. compression
    2. injection
    3. heat sealing
    4. thermoforming

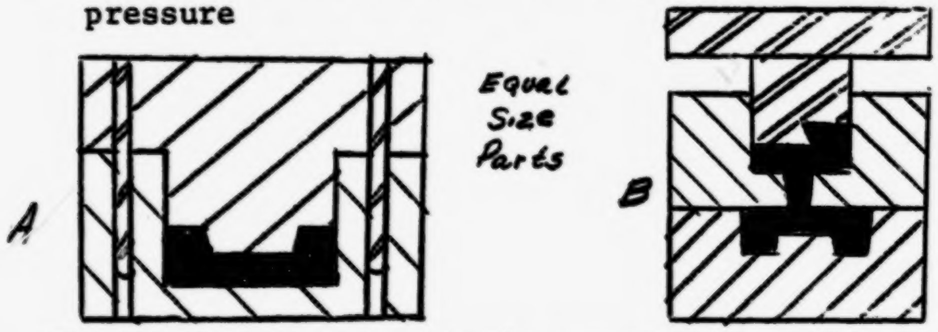


40. Which of the following plastics materials should be chosen to make a flame resistant thermoplastic part by injection molding?
    1. cellulose nitrate
    2. cellulose acetate
    3. melamine
    4. alkyd

41. Which one of the following plastics processes is represented by the diagram below?
    1. compression
    2. injection
    3. heat sealing
    4. thermoforming



42. Of the two processes shown in diagrams A and B below:
    1. A requires more molding pressure than B
    2. B requires more molding pressure than A
    3. both require the same molding pressure
    4. one cannot determine which requires the greatest molding pressure

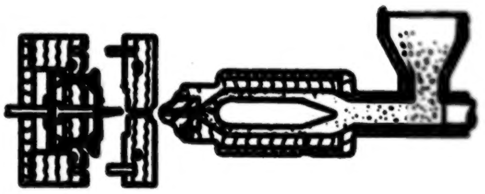


43. The two halves of a simple compression mold are called
    1. force and cavity
    2. drag and force
    3. drag and cavity
    4. force and platen

44. In terms of growth in pounds per year for 20 year periods, the plastics industry grew at the highest rate between the years:
    1. 1882 to 1902
    2. 1902 to 1922
    3. 1922 to 1942
    4. 1942 to 1962

45. When a cake is baked it acts similar to the change which heat makes on:
    1. thermoplastics
    2. thermosetting plastics
    3. thermofusion
    4. thermoforming

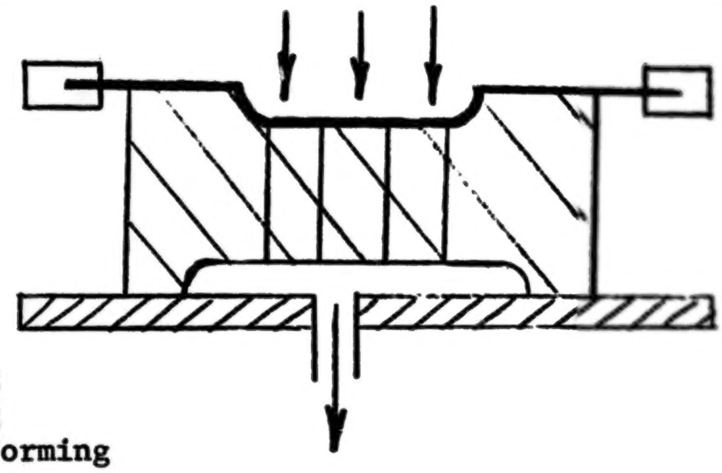
46. Which plastics process is represented by the following diagram?



    1. compression molding
    2. injection molding
    3. heat sealing
    4. thermoforming

47. A transparent thermoplastic which is used for signs and tail light lenses is:
    1. acrylic
    2. cellulosic
    3. nylon
    4. ABS

48. Which plastics process is represented by the following diagram?



    1. blow molding
    2. blow forming
    3. mechanical forming
    4. vacuum forming

49. John Wesley Hyatt discovered:
    1. the first commercial molding technique
    2. the second commercial plastic
    3. cellulose nitrate
    4. phenolics

50. How much total force is necessary when compression molding phenolic molding compounds with a surface area of 2 square inches?
    1. 2500 pounds
    2. 4000 pounds
    3. 6000 pounds
    4. 8000 pounds

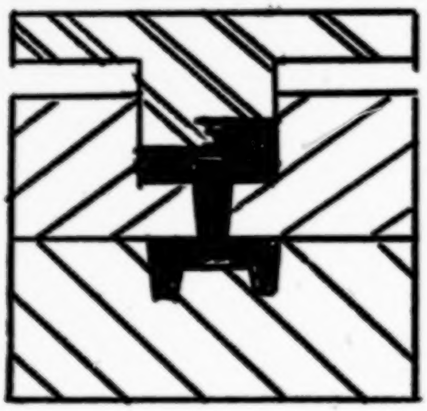
51. Placing a soft thermoplastic tube into a mold, closing the mold over the tube and using air pressure to form it against the mold is called:
    1. injection molding
    2. thermoforming
    3. blow molding
    4. thermofusion

52. The molecular structure of cured thermosetting plastics is in the form of:
    1. flexible structures
    2. free structures
    3. chain like structures
    4. cross linked structures

53. After ejection from an injection mold the part is cut from its:
    1. gate
    2. sprue
    3. sprue and runners
    4. nozzle

54. In injection molding, one product of a complete molding cycle is called:
    1. family
    2. shot
    3. gate
    4. part

55. Which type of plastic material would be used in the mold diagrammed here?
    1. thermoplastic
    2. thermofusion
    3. thermoforming
    4. thermosetting



56. Plastics companies which produce basic plastics chemicals for use by the industry are known in the plastics industry as:
    1. plastics materials manufacturers
    2. fabricators and finishers
    3. processors
    4. supply houses

57. Which of the following methods would you choose to thermoform a part which requires fine details to be on the outside surface?
    1. vacuum cavity forming
    2. vacuum drape forming
    3. free blowing
    4. mechanical stretch forming

58. A compression mold which will not allow excess material to escape during compression is called:
    1. fully positive mold
    2. flash mold
    3. semi-positive mold
    4. landed positive mold

59. Forming plastic sheet or film between rollers:
    1. coating
    2. calendering
    3. laminating
    4. reinforcing

60. A strong self lubricating plastics material used for bearings:
    1. vinyls
    2. acetal
    3. nylon
    4. cellulosics

61. A high strength, high adhesion thermosetting plastics material used for glues and coatings is:
    1. casein
    2. polyester
    3. polyurethene
    4. epoxy

62. Which of the following materials should be chosen to thermoform a freezer door liner to give maximum impact strength and rigidity, disregarding cost?
    1. hi-impact polystyrene
    2. acrylic
    3. ABS
    4. cellulosic

63. Of the following stages in the thermoforming process, before heating the plastic sheet one usually will:
    1. form the sheet
    2. clamp the sheet
    3. cool the sheet
    4. trim the part

64. Which of the following materials should be chosen for a small, low cost, sturdy, opaque sign to be vacuum formed?
    1. hi-impact polystyrene sheet
    2. ABS sheet
    3. polypropylene sheet
    4. acrylic sheet

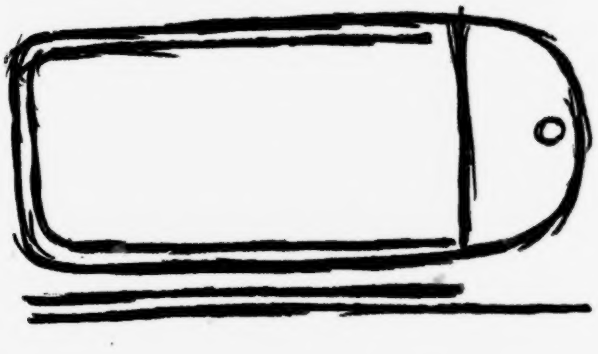
65. Transfer molding uses the same molding materials as:
    1. blow forming
    2. thermoforming
    3. extrusion molding
    4. compression molding

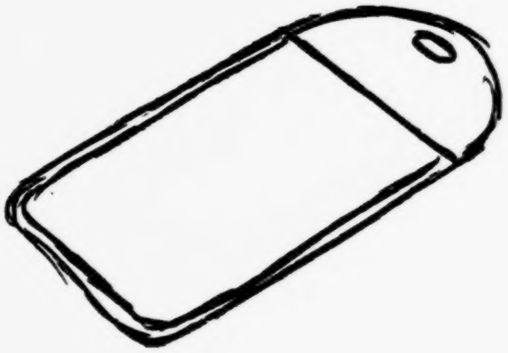
66. A plastics process which utilizes the formability of plastic sheet is called:
    1. thermofusion
    2. thermoplastics
    3. thermosetting
    4. thermoforming

67. Which of the following plastics made television and radar possible?
    1. polyester
    2. polyethylene
    3. polystyrene
    4. polyether

68. Which of the following processes should be selected to produce a thin, inexpensive, flexible plastic key case as diagrammed?

    1. injection molding
    2. heat sealing
    3. compression molding
    4. hot gas welding





69. The joining of two or more pieces of thermoplastic film by heat and pressure is called:
    1. heat sealing
    2. welding
    3. thermofusion
    4. thermoforming

70. In 1964 consumption of plastics materials has surpassed the rate of:
    1. 5 billion pounds per year
    2. 7.5 billion pounds per year
    3. 10 billion pounds per year
    4. 20 billion pounds per year

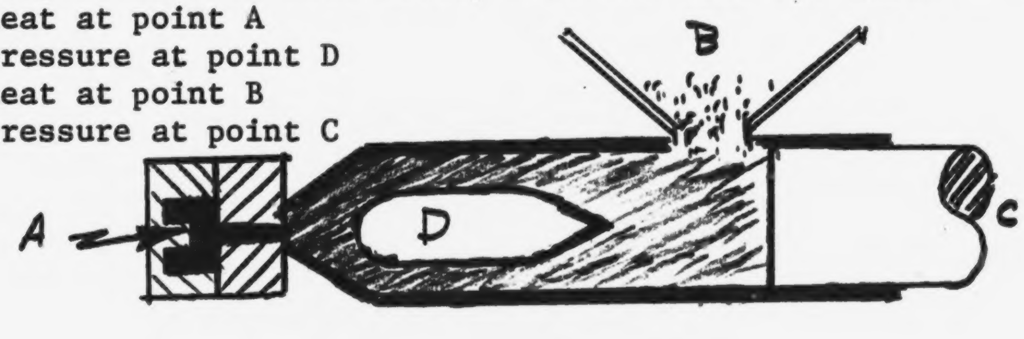
71. Which method would be most successful in thermoforming for a deep draw on a thick, hard to form sheet?
    1. high vacuum forming
    2. high pressure blow forming
    3. low pressure mechanical stretch forming
    4. vacuum forming and mechanical assist

72. Allowing the molecular bond in plastics to slip will:
    1. destroy the plastics material
    2. produce a formable material
    3. make the plastics material harder
    4. produce a chemical change in the material

73. A strong, dark colored, hard to scratch thermosetting plastics material with good electrical insulation properties which is often used for electric iron handles and appliance bases:
    1. polyurethene
    2. silicone
    3. epoxy
    4. phenolic

74. The most common thermoforming method is:
    1. mechanical forming
    2. vacuum forming
    3. blow forming
    4. thermofusion forming

75. In order to get material into cavity A of the mold one must:
    1. apply heat at point A
    2. apply pressure at point D
    3. apply heat at point B
    4. apply pressure at point C



76. What type of a change takes place in a thermoplastic when heated and cooled?
    1. chemical
    2. physical
    3. electrical
    4. mechanical

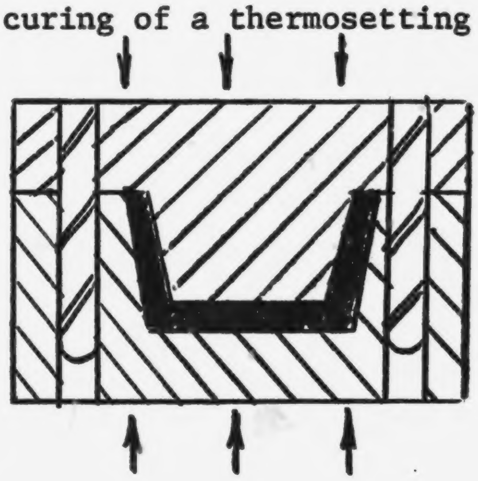
77. If you were designing a full size sports car body to be made of plastic and the production run was expected to be short (5 units) which of the following methods would you use for maximum strength and economy?
    1. injection molding
    2. compression molding
    3. thermoforming
    4. thermofusion

78. A tough, low friction thermoplastic which is used to coat the inside of frying pans and other kitchen utensils:
    1. vinyl
    2. polyfluorocarbon
    3. nylon
    4. polycarbonate

79. When materials which increase the bulk factor are added to a phenolic compound, what must be added to off-set the reduced flow?
    1. plasticizers
    2. fillers
    3. pigments
    4. preforms

80. Of the following machines, which can be used successfully to join thermoplastic parts by friction welding?
    1. circular saw
    2. hand drill
    3. drill press
    4. band saw

81. In order to complete the curing of a thermosetting material in this mold one must:
    1. add more material
    2. add heat
    3. add more pressure
    4. cool the mold



82. A process, called skin packaging where a thin plastic film is drawn down over a hard goods item like a tool, is a variation of:
    1. thermofusion
    2. window packaging
    3. vacuum forming
    4. blow packaging

83. In order to assure a complete injection molded part one must:
    1. keep the mold hot to prevent cooling too rapidly
    2. hold the pressure on the injected material for an instant after filling the mold
    3. allow the mold to breath after injection
    4. purge the nozzle frequently

84. A tough, pliable, waxy thermoplastics material which is used for protective sheeting and housewares is:
    1. epoxy
    2. polystyrene
    3. polyethylene
    4. polycarbonate

85. If you had a plastics processing machine with the following parts: 1) a torpedo; 2) heating bands, and 3) a hopper, you would have:
    1. a compression molder
    2. an injection molder
    3. a laminator
    4. a thermoformer

86. From the following list, select the material which is not a common thermosetting material:
    1. phenolic
    2. urea
    3. acrylic
    4. melamine

87. Plastics which soften when heated and harden when cooled are called:
    1. thermosetting plastics
    2. thermo-curing plastics
    3. thermoplastics
    4. cold molded plastics

88. A continuous pushing of a thermoplastic material through a die to form a continuous plastic part is called:
    1. injection molding
    2. compression molding
    3. thermoforming
    4. extrusion molding

89. Recently plastics have been replacing a number of materials for commercial fabrication of all kinds of products and containers. The most important three of those replaced are:
    1. metal, glass and ceramics
    2. wax, glass and wood
    3. ivory, shellac and rubber
    4. ceramics, shellac and wax

90. The joining of two pieces of thick thermoplastic sheet material by heat and a plastic rod is called:
    1. heat sealing
    2. welding
    3. thermofusion
    4. thermoforming

91. How can a melamine, urea or phenolic compound be condensed to decrease the bulk factor and fit it into the mold better?
    1. cure it
    2. add fillers
    3. weigh it properly
    4. preform it

92. Casein plastics are made from:
    1. coal
    2. oil
    3. cow's milk
    4. soy beans

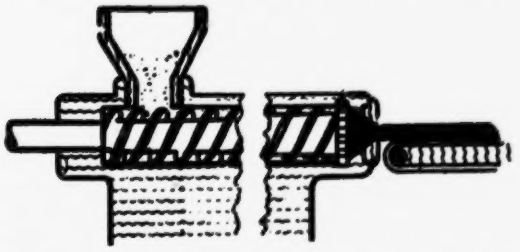
93. A strong, tough thermosetting plastics material used for counter tops and plastic dinnerware is:
    1. urea
    2. melamine
    3. phenolic
    4. vinyl

94. Two natural resinous materials which act similar to plastics but came before the discovery of plastics are:
    1. rubber and shellac
    2. wood and coal
    3. alkyds and epoxies
    4. nylons and phenols

95. Plastics which cure into permanent shape when heated are called:
    1. thermo-curing plastics
    2. thermosetting plastics
    3. thermoplastics
    4. hot molded plastics

96. The middle stage in the molding cycle of a compression molding compound is:
    1. flow stage
    2. preform stage
    3. pellet stage
    4. cure stage

97. Which plastics process is represented by the following diagram?



    1. heat sealing
    2. blow molding
    3. extrusion
    4. thermosealing

98. BAKELIGHT is the trade name for a plastics material developed by:
    1. John Hyatt
    2. Leo Baekeland
    3. Adolph Spitteler
    4. Eric Paulson

99. If you were going to manufacture a product containing injection molded parts, which of the following types of plastics manufacturers would you buy these injection molded parts from:
    1. a plastics material manufacturer
    2. a fabricator and finisher
    3. a processor
    4. a chemical house

100. In injection molding of thermoplastics, three elements provide the path for the material to the cavity. Which of the following elements is closest to the nozzle of the molder?
    1. sprue
    2. runner
    3. gate
    4. hopper

101. Plastics is a family of synthetic organic materials made up of:
    1. heavy atoms
    2. large molecules
    3. small molecules
    4. light atoms

102. The most common method of manufacturing thermoplastic sheet materials used for thermoforming is:
    1. calendering
    2. casting
    3. laminating
    4. extruding

103. If the molding surface size is increased in compression molding:
    1. the total clamping pressure needed is decreased
    2. the heat required for cure is increased
    3. the total clamping pressure needed is increased
    4. the heat required for cure is decreased

104. Purging the cylinder on an injection molder is necessary to:
    1. keep it from leaking
    2. check the material temperature
    3. change materials or colors
    4. check material colors

105. Hot gas welding is used most successfully for:
    1. thin plastic film
    2. thick plastic sheet
    3. thin plastic sheet
    4. thick plastic film

106. The molecular structure of a thermoplastic is in the form of:
    1. large free structures
    2. small free structures
    3. chain like structures
    4. cross linking structures

107. At what angle should the rod be to the material in hot gas welding of thermoplastics material?
    1. right angles to the work
    2. slight angle to the rear
    3. at 45° to the work
    4. at 30° to the work

108. Hot gas welding of plastics is most similar to:
    1. arc welding of metals
    2. gas welding of metals
    3. heat sealing
    4. induction welding

109. Which one of the following plastics made fiberglass reinforced plastics practical?
    1. celluloid
    2. casein
    3. silicone
    4. polyester

110. The plastics material which is most successfully hot gas welded is:
    1. acrylic
    2. allylic
    3. polyvinyl chloride (PVC)
    4. ABS

111. A tough thermoplastics material which remains quite flexible at low temperatures is:
    1. polyesters
    2. epoxy
    3. acrylic
    4. ABS

112. In heat sealing of thermoplastic materials by heated tool methods the materials are sealed by:
    1. heat and pressure
    2. pressure sensitive adhesives
    3. friction
    4. heat induction

113. The pressing of a powder or pellet thermosetting plastics material into a hot mold cavity is called:
    1. extrusion molding
    2. injection molding
    3. thermofusion molding
    4. compression molding

114. Shaping heated thermoplastic sheet by pressure is called:
    1. compression molding
    2. thermoforming
    3. injection molding
    4. heat sealing

115. The mold used in vacuum forming of thermoplastic sheet where the sheet is drawn into the mold is called an:
    1. cavity mold
    2. drape mold
    3. inside mold
    4. contact mold

116. Injection molding is a plastics molding process which is most similar to which of the following metal processes:
    1. green sand casting
    2. die casting (hot chamber)
    3. sheet forming
    4. shell molding

Appendix C Selected Reference Materials

C-1 Suggested Equipment List (New York)

C-2 Seventh Year Outline (New York)

C-3 Gates Chili Outline

C-4 Teaching Plastics - Article

C-5 An Introduction to Plastics - Article

C-6 Basic Reference Library for Plastics

C-7 Test of Equipment Used

Appendix C-1

Suggested Equipment List for Plastics*

24 students

Junior and/or Senior High School

No.	Description	Cost
(2)	1/5 ounce or larger Injection Molding machine, Simplomatic PL-63 or equal -- Jr. and Sr. High Sources: 5, 7, 22, 32, 38 @$300.00	$600.00
(4)	Mold blanks for above Injection Molder -- Jr. and Sr. Sources: 5, 7, 22, 32, 38 @$10.00	40.00
(1)	12 ton or larger capacity, Compression/Laminating press complete with heated and cooled platens facing sheets for laminating, thermometers and 1 compressed mold, etc. Carver Model 150 or Pasadena Hydraulics Labmaster or equal -- Jr. and Sr. Sources: 5, 8, 12, 35a, 39, 44 @$550.00	550.00
(1)	Vacuum former 7" x 7" with vacuum source and heating unit, Iasco 7" x 7" or equal -- Jr. High Source: 24	80.00
(1)	Vacuum former 10" x 14" with vacuum source and heating unit, Orbit Model SA-2500 or equal -- Jr. High - Sources: 4, 5, 10, 24, 43	145.00
(1)	Portable Scrap Granulator 7" x 6-1/2" throat or larger capacity with 1 Hp motor and switch, Injection Molders Supply Co. Model M-1 or equal -- Sr. High. Source: 26	450.00
(1)	Vacuum, pressure and mechanical former 18" x 18" with heating unit, material clamping device, vacuum and pressure sources, Di-Acro Model 18 with hinged clamp frame or equal -- Sr. High. Sources: 5, 14	875.00
(1)	Vacuum former, 10" x 14" with vacuum source and heating unit, Orbit Model SA-2500, or equal -- Sr. High. Sources: 4, 5, 10, 24, 43	145.00

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*From an Experimental Resource Unit in Plastics for Industrial Arts (p. 190-91).

No.	Description	Cost
(1)	Electric oven and burner unit, electric kitchen stove with large oven and four surface cooking units, 30" or 40" with wide oven or equal -- Jr. and Sr. High. Source: Local hardward store	325.00
	OR	
	Hot air oven, thermostatically controlled, 450 or higher maximum temperature, interior minimum dimensions 26" wide by 20" high x 20" deep -- Broadhead-Garrett Model 51-550 or equal -- Jr. and Sr. High. Sources: 1, 11, 13, 16, 19, 23, 24	383.00
	AND an electric hot plate, 2 burner 1500 to 2000 watts per burner, multi-speed burner control Source: Local hardware store	30.00
(1)	Strip heater 18" long or longer, Hotpack 18" or equal. Sources: 5, 11, 23, 24 -- Jr. and Sr.	22.50
(1)	Heat Sealer, hand operated, Caig Lab. Model Ersa #50p, 150p or 50F or equal -- Jr. and Sr. High Sources: 6, 20, 37, 42, 48	15.00
(1)	Plastics Welding Unit, hand operated, kit with extra tips, etc. Kamweld 15 TM or equal -- Jr. and Sr. High. Sources, 5, 7, 27, 48	105.00
(1)	Glue pot or bucket heater unit for cold dripping. Sources: 5, 20. Jr. and Sr. High	25.00
(1)	Engraving machine, Micro Model or equal - Sr. High. Sources: 18, 21, 31	150.00
(1)	Hot stamping machine, Kingsley or equal -- Sr. High. Sources: 2, 28, 30	295.00
(1)	Thermometer, 6" shank, dial face reading type 100°F to 600°F, Weston or equal -- Jr. and Sr. High. Sources: 49	
(1)	Power paint mixing paddle -- Jr. and Sr. High Source: Local hardware story	1.00
(2)	Double wheel electric buffer, 6" wheel or larger, 1/2 Hp or larger, 1725 RPM -- Sr. High Sources: 5, 11, 24 @$50.00	100.00
	Assorted molds, jello molds, muffin pans, glass tumblers, leaf molds, casting molds -- Jr. and Sr. High. Sources: Local hardward store	25.00

No.	Description	Cost
(1)	Pressure cooker, 10 qt. or larger -- Jr. and Sr. Source: Local stores	20.00
(3)	Air pressure regulators, 0 to 100 psi, single stage, spray painting type @$30.00 -- Jr. and Sr. Sources: Local automotive supply stores etc.	90.00
(1)	Air compressor -- capacity at least equal to the air consumption of two air operated injection molders with necessary valves, hose, quick connectors -- Jr. and Sr. High Source: Local	350.00
(2)	Air line oilers for injection molders -- Jr. and Sr. High. Source: Local	20.00
(1)	Postal scales, 2 lbs. capacity, spring type for weighing materials -- Jr. and Sr. High Source: Local	5.00
(1)	Electroplating unit, 5 amp. capacity or larger power unit and plating equipment and chemical set, Warner 5 amp. power unit #971 x plus plating outfit #3 -- Jr. and Sr. High Sources: 5, 35b	110.00

Appendix C-2

Seventh Year Outline

Plastics Area in General Industrial Arts*

Unit No.	Demonstrations and Related Lessons (D) (R)	Suggested time allotment for instruction
1	History, Application, Classification	3-15 min. lessons (R)
2	Injection molding, Extrusion, Blow Molding, Compression Molding	2-30 min. lessons (R)
2	Injection molding, Compression molding and Thermoforming	3-15 min. lessons (D)
3	Moldmaking--all materials	1-30 min. lesson (R)
3	Moldmaking--gypsum	1-30 min. lesson (D)
4	Bonding--cementing, heat sealing, welding	1-20 min. lesson (R) 1-20 min. lesson (D)
5	Laminating--Reinforced Plastics low pressure and high pressure	2-15 min. lessons (R) 2-15 min. lessons (D)
6	Encapsulation and Embedding	1-15 min. lesson (R) 1-15 min. lesson (D)
7	Foams--bead and resin	1-10 min. lesson (R) 1-10 min. lesson (D)
8	Coating--cold dip and fluidized bed	1-10 min. lesson (R) 1-10 min. lesson (D)
9	Vinyl Dispersions and Rotational Molding	1-10 min. lesson (R) 1-10 min. lesson (D)

Note: This outline suggests twenty-four (24) lessons.

Total suggested teaching time--400 minutes (equal to 10-40 minute lessons).

A great deal of pupil project and/or experimental activity can be combined with woodworking and ceramics. For example: moldmaking, which requires wooden flasks and gypsum casting.

*From An Experimental Resource Unit in Plastics for Industrial Arts (p. 184)

Appendix C-3

GATES CHILI SENIOR HIGH SCHOOL
910 Wagman Road
Rochester 11, New York
DEPARTMENT OF INDUSTRIAL ARTS

WEEKS OF INSTRUCTION - 40
DAYS PER WEEK - 5
PERIODS PER DAY - 1 (45 minutes)
UNITS OF CREDIT - 1

UNITS OF INSTRUCTION

UNIT I HISTORICAL DEVELOPMENT OF PLASTICS
- a. What Plastics are used for
- b. Basic History of Plastics
- c. The Industrial Development of Plastics Industry

UNIT II PLASTIC DESIGN AND PRODUCT DEVELOPMENT
- a. Product Development in regard to material
- b. Developing a Pilot Model
- c. Decoration of Plastic Products

UNIT III PLASTIC CHEMISTRY
- a. Preparing a plastic material
- b. Major Sub-divisions of Plastics
- c. Identification of plastics
- d. Coloring plastics
- e. Modifying plastics
- f. Solvents for plastic materials

UNIT IV Characteristics of PLASTICS
- a. Acrylic
- b. Alkyd
- c. Cellulosic
- d. Epoxy
- e. Fluorocarbon
- f. Melamins
- g. Polyamide
- h. Phemolic
- i. Polyester
- j. Polyethylene
- k. Polystrene
- l. Silicons
- m. Urea
- n. Vinyl

UNIT V PROCESSING PLASTICS
- a. Compression Molding
- b. Transfer Molding
- c. Pulp Molding
- d. Injection Molding
- e. Blow Molding
- f. Solvent Molding

g. Extrusion
h. Casting
i. Laminating

UNIT VI THE MANUFACTURING PROCESSES
a. Molded
b. Extruded
c. Calendared
d. Laminated
e. Cast
f. Bonding Agents
g. Reinforced Materials
h. Surface Coatings
i. Foams

UNIT VII WORKING WITH FIBER GLASS
a. Materials, equipment and process
b. Mold construction
c. Laminating methods
d. Trimming and finishing
e. Decorating techniques
f. Industrial application

UNIT VIII PRESSURE FORMING OF PLASTICS
a. Material, equipment and process
b. Mold or Die design
c. Vacuum Forming
d. Blow Molding
e. Pressure and Heats for forming
f. Trimming and finishing

UNIT IX CASTING PLASTIC MATERIALS
a. Materials, equipment and process
b. Mold design and material
c. Centrifugal Casting
d. Drain Casting a plastic
e. Casting Foam plastics

UNIT X INJECTION MOLDING OF PLASTICS
a. Materials, equipment and process
b. The injection machine
c. Mold Design
d. Mold Construction
e. Consideration when planning production

UNIT XI WORKING WITH EPOXY PLASTICS
a. Materials, equipment and process
b. Safety in working with epoxy resins
c. Mold and Die work from epoxies
d. Fastening with epoxy cement
e. Reinforcing with epoxy resins

UNIT XII THE FUTURE OF PLASTICS

a. The industrial activities of the future
b. Employment possibilities
c. Advanced schooling in plastics
d. New plastic products of the future

MAKE CONTACTS WITH:	TELEPHONE
James E. Hatch, Chairman Department of Industrial Arts Gates Chili High School 910 Wagman Road Rochester 11, New York	FA8-2101

special report

Teaching Plastics

GERALD L. STEELE

Mr. Steele is chairman of the Industrial Arts department, Orono Public Schools, Long Lake, Minn.

■ Much has been said and written, recently, about the importance of the plastics industry and its products in our modern technological society. This industry has been described as the fastest growing in the United States. It probably has brought more new products and materials onto the market in the last five years than any other industry. "Cheap" plastic products are no longer being produced. Quality and quantity are the order of the day now.

These advances have not, however, been matched by advancement in knowledge of plastics materials, processes and technology by the prospective worker, designer, manager or consumer.

Some serious efforts to begin teaching students about the new plastics are beginning to manifest themselves. Most industrial arts teachers and many teacher educators lack the skills and knowledges needed concerning plastics. This was shown in a recent survey taken in Minnesota. Out of 246 industrial arts instructors who taught plastics, only eight felt that they were well trained in plastics. This is compared with over 50% to 60% of the instructors teaching other industrial arts subjects who felt that they were well trained in their subject area. For this reason, plastics has not developed as it should into a major area of the industrial arts curriculum. It cannot be classified as a craft area any longer. The plastics industry is not a craft industry.

Instructional materials such as books, film strips, films, teaching aids, processing machines, wall charts, and curriculum guides have been difficult to obtain. Many of them do not exist. Teachers do find these materials readily available for the other areas of industrial arts, so they tend to teach in the areas where information and materials are available.

There is a need to develop the above mentioned materials for plastics and organize curriculum workshops and extension classes.

Why Needed

Plastics should be taught in the schools in order to familiarize the students with the plastics industry, its materials and processes. The industry needs people for management, production control, designing and production. They must have a good knowledge of the field commensurate with their need. In addition the industry needs a consuming public that is literate about plastics.

How to Organize a Plastics Unit

Plastics units may be organized around any one of several schemes. The courses may center around certain processes, materials and processing machines. They may be divided into two groups according to their classification — (1) thermosetting and (2) thermoplastics. Another method is to develop the courses according to the level of the student's ability.

Generally, where more than one course is taught, a basic or exploratory course or unit should precede the specialized courses. The advanced courses can then be organized around the classifications of thermosetting and thermoplastic or any other convenient arrangement.

Finally the advanced unit or course should center around mold making, design and fabrication on a mass production basis. Mold making and design are so much a part of the industry that every effort should be made to include it wherever possible. Mass production, on a small scale, can also be accomplished in the beginning courses or units.

Where to Start

In order to contact as many students as one can, the first unit should be offered in the seventh or eighth grade. Courses should then be offered in as many later grades as possible. The background in the high school would then provide him with usable knowledges and skills for entering into plastics engineering, management, technology or employment.

Suggested Units in Plastics

Several plastics units and courses which have been developed are included here. These have been designed for the situation in Minnesota but can easily be adapted to other states. Available equipment will necessarily limit the instruction in some areas. When this equipment does become available these areas can be added to the courses.

Each of these courses should be expanded from the outline given and a complete course of study written which will fit the needs and facilities for which it will be used.

Suggested Objectives for Plastics Education

Here are several suggested objectives for plastics. These may be adapted to the individual teaching situation in whole or part as the conditions exist.

1. To interpret the plastics industry to the student.
2. To develop a knowledge of the materials, processes and products of the industry.
3. To develop a knowledge of the history and growth of the industry.
4. To develop correct methods for working with plastics materials and processes.
5. To develop safe working habits with the machines and tools of industry.
6. To develop a sense of design and the ability to apply it to materials.
7. To develop consumer knowledges concerning plastic materials and products.
8. To develop vocational interests in occupations relating to plastics.

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Plastics Curriculum

Unit I — Exploratory Plastics

Grade 7 or 8 4 to 6 Weeks

A. Introduction to plastics

1. History and growth of the industry
2. Types and kinds of plastics
3. Plastic molding processes
4. Fabrication and finishing methods

B. Teaching Methods

1. Demonstrations of all the mold and fabrication types below
2. Projects
    a. Sheet acrylic plastics
    b. Vacuum forming of sheet plastics and blow forming of sheet plastics
    c. Mechanical stretch forming of sheet plastics
    d. Expandable bead foam
    e. Resin foam
    f. Thermofusion of pellets and powders
    g. Fiber glass lamination
    h. Vinyl plastisol casting
    i. High pressure laminating
    j. Rotational casting and molding
    k. Compression molding
    l. Injection molding
3. Lectures — as necessary for the above units
4. Field trips — local plastics industries, if available.

C. Films and Film Strips

1. "Talking Plastics" FS, Society of the Plastics Industry, 250 Park Ave.. New York 17, N. Y.
2. "Loma Story" F, Loma Industries, 3000 Pafford St., Fort Worth, Tex.
3. "Forming Plastics Sheet Materials" F, Di Acro Corp., Lake City, Minn.
4. "Origin and Synthesis of Plastic Materials" F, SPI, 250 Park Ave., New York 17, N. Y.
5. "Methods of Processing Plastics" F, SPI, 250 Park Ave., New York 17, N. Y.
6. "Designing with Reinforced Plastics" FS, SPI, 250 Park Ave., New York 17, N. Y.
7. "The Shape of Plastics" F, SPI, 250 Park Ave., New York 17, N. Y.
8. "The Composition & Properties of Plastics" F, SPI, 250 Park Ave., New York 17, N.Y.
9. "The Manufacture of Plastics" F, SPI, 250 Park Ave., New York 17, N. Y.
10. "Prospect for Plastics" F, SPI, 250 Park Ave., New York 17, N. Y.

*11. "Plastics: Industrial Processes & Products" F, SPI, 250 Park Ave., New York 17, N. Y.

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*Note: See Film Catalog, Society of the Plastics Industry, 250 Park Ave., New York 17, N. Y., for additional films. FS = Film Strip & F = Film.

D. Texts and References

1. Bakelite Corp., *The A.B.C.'s of Modern Plastics*, New York 17, N. Y.
2. Bick, Alexander, *Plastics: Projects & Procedures with Polyesters*, Bruce, Milwaukee, 1962
3. Cherry, Raymond, *General Plastics, Revised*, McKnight & McKnight, Bloomington, Ill., 1964
4. Cope, Dwight, *Cope's Plastics Book*, Goodheart-Willcox, Chicago, Ill., 1960
5. Edwards, Lauton, *Making Things of Plastics*, Bennett, Peoria, Ill., 1954
6. Owens-Corning Fiberglass Corp., *Fiberglass Reinforced Plastics*, 5–PL1998A
7. SPI, *Plastics Engineering Handbook*, Reinhold Pub. Co., New York 22, N. Y., 1960
8. SPI, *Plastics — Story of an Industry*, Society of the Plastics Ind., New York 17, N. Y.
9. Steele, Gerald, *Fiber Glass — Projects & Procedures*, McKnight & McKnight, Bloomington, Ill., 1962
10. Swanson, Robert, *Plastics*, McKnight & McKnight, Bloomington, Ill. 1964

E. Evaluation

1. Tests
2. Quizzes
3. Projects—size, shape, quality, quantity, etc.

Unit II — Fiber Glass and Foam Plastics

Grade 8 or 9 4–8 Weeks

A. Introduction to fiber glass and foam plastics

1. History and growth of the industries
2. Types of fiber glass and foams
3. Molding processes
4. Fabricating processes
5. Project selection and planning

B. Teaching Methods

1. Lecture — as necessary for introduction and processes
2. Demonstrations — all methods to be used and advanced methods to promote thinking
3. Projects — Fiber Glass
    a. Required
        1. Flat contact molded
        2. Low curved, pressure molded
    b. Optional
        1. Larger, advanced (chairs, etc.)
        2. Student designed and built
4. Psojects — Expanded Beads
    a. Required
        1. Virgin bead project
        2. Expanded bead project
    b. Optional
        1. Design and build simple mold — spun, cast, etc.
5. Projects — Resin Foam
    a. Required
        1. Open mold
        2. Foam in place — in combination with vacuum forming, etc.
    b. Optional
        1. Design and build open mold
        2. Design foam in place
6. Field Trips
    a. Fiber glass industry
    b. Foam industry(s)
7. Evaluation — Quizzes, tests, projects, etc.

C. Films and Film Strips

1. "Designing with Reinforced Plastics" FS, Society of the Plastics Industry, Inc., 250 Park Ave., New York 17, N. Y.
2. "Magic Fibers" F, Owens-Corning Fiberglass Corp., New York, N. Y.
3. "Born of Foam" F, Koppers Co., Plastics Div., Pittsburgh, Pa.

D. Texts and References

1. Bell, Chas., *How to Build Fiberglass Boats*, Coward-McCann, New York 16, N. Y., 1957
2. Bick, Alexander, *Plastics: Projects & Procedures W/Polyesters*, Bruce, 1962
3. Koppers Co., *Dylite Polystyrene Series*, Koppers Co., Pittsburgh, Pa.
4. Owens-Corning Fiberglas Corp., *Fiberglas Reinforced Plastics*, 5-PL-1998A, New York 22, N. Y.
5. Sonneborn, Ralph, *Fiberglas Reinforced Plastics*, Reinhold, New York 22, N. Y.
6. SPI, *Plastics Engineering Handbook*, Reinhold Pub., New York 22, N. Y., 1960
7. Steele, Gerald, *Fiber Glass — Projects & Procedures*, McKnight & McKnight, Bloomington, Ill., 1962
8. Swanson, Robert, *Plastics*, McKnight & McKnight, Bloomington, Ill., 1964

E. Articles

1. Daines, James, "Expandable Polystyrene Without Steam, *Ind. Arts & Voc. Ed.*, April, 1963, p. 61
2. Johnson, Ira, "Expandable Polystyrene: Projects Unlimited," *School Shop*, September, 1961
3. *Modern Plastics Magazine & Encyclopedia*, Emmett Street, Bristol, Conn.
4. Shields, Robert, "Plastics: The New Material for the New Age," *School Shop*, April, 1962, p. 61

Unit III — Experimental Plastics and Fabrication

Grade 9 or Above

This unit can be combined with wood or metal or used alone. The combination of materials which is suggested here makes this possible.

A. Introduction

1. Review of the plastics industry
2. Review of the plastics types and kinds
3. Review of the molding processes

4. Study of the possibilities of material combinations
5. Selection of projects and planning
6. Selection of areas of work. Students can be given a choice of the types of plastic fabrication he will employ.

B. Teaching Methods

1. Advanced Thermoforming
   a. Demonstrations
      1. Drape or cavity forming
      2. Free and controlled blowing
      3. Combination, plug, vacuum and/or blow.
   b. Projects (Choose one)
      1. Combine with wood
      2. Combine with metal
      3. Combine with plastics
2. Advanced Fiber Glass
   a. Demonstrations
      1. Duplication molds
      2. Deep molds
      3. Combined with other materials
      4. Larger molds (chairs, etc.)
   b. Projects (Choose one)
      1. Advanced types as above
      2. Combination types
3. Advanced Foams
   a. Demonstrations
      1. Different types of molds for resin foams
      2. Spun aluminum and cast molds for foam beads
   b. Projects (Choose one)
      1. Two-piece cast molds
      2. Flat back molds
      3. Spun molds
      4. Student designed molds
4. Vinyl Plastisols and Thermofusion of Plastics
   a. Demonstrations
      1. Casting plastisols
      2. Thermofusion of powdered polyethylene and pelleted polystyrene
   b. Projects
      1. Casting Plastisols
      2. Thermofusion
      3. Student designed mold
5. Field Trips
6. Lectures — covering the necessary areas

C. Films and Film Strips

1. "Designing with Reinforced Plastics," FS, Society of the Plastics Industry
2. "Plastics: Industrial Processes and Products," F, SPI, New York 17, N. Y.
3. "Forming Plastic Sheet Materials," F. Di-Acro Corp., Lake City, Minn.
4. "Born of Foam," F, Koppers Co., Pittsburgh, Pa.

D. Texts and References

1. Bick, Alexander, *Plastics: Projects and Procedures W/Polyesters*, Bruce
2. Cherry, Raymond, *General Plastics, Revised*, McKnight & McKnight, Bloomington, Ill., 1964
3. Modern Plastics Magazine and Encyclopedia
4. Sonneborn, Ralph, *Fiberglass Reinforced Plastics*, Reinhold Pub., New York 22, N. Y.
5. SPI, *Plastics Engineering Handbook*, Reinhold, New York 22, N. Y.
6. Steele, Gerald, *Fiberglass — Projects and Procedures*, McKnight & McKnight, Bloomington, Ill., 1962
7. Swanson, Robert, *Plastics*, McKnight & McKnight, Bloomington, Ill., 1964
8. Willis, John, *Glass Fiber Auto Body Construction*, Post, Arcadia, Calif.

E. Evaluation

1. Quizzes
2. Tests
3. Projects

Unit IV — Advanced Plastics Fabrication and Design

High School Grades 11 & 12
36 Weeks

Desirable Prerequisites. Hand woodworking, Machine woodworking, 1 or 2 Semesters of General Drafting, Machine metalworking, and Units I, II, & III of this Plastics Curricula.

A. Introduction

1. Understanding the plastics industry
   a. History and growth
   b. Organization of the industry
   c. Future of the industry
   d. Job opportunities in the industry
2. Outline of the plastics types and kinds
3. Outline of the molding processes
4. Outline of the fabrication and finishing methods
5. Outline of the design of products and molds
6. Guidelines for tool and die making

B. Demonstrations and Lectures of Plastics and Molds

1. Plaster mold for:
   a. Fiber glass
   b. Vacuum forming
   c. Patterns
   d. Expandable resins
2. Machined metal molds for:
   a. Compression molding
   b. Extrusion molding
   c. Injection molding
   d. Transfer molding
3. Cast metal molds for:
   a. Thermofusion
   b. Plastisols
   c. Expandable beads
   d. Expandable resins
4. Glazed china molds for:
   a. Casting resins
   b. Fiber glass
   c. Vacuum forming
5. Wood molds for:
   a. Vacuum forming
   b. Blow forming
   c. Fiber glass
   d. Expandable resins
6. Fiber glass molds for:
   a. Fiber glass
   b. Casting resins
   c. Vacuum forming
   d. Blow forming
   e. Expandable resins
7. Spun metal molds for:
   a. Expandable beads
   b. Expandable resins
   c. Fiber glass
8. Press designs for:
   a. Air operation
   b. Hydraulic operation
   c. Steam operation
   d. Mechanical screw operation

C. Projects

(Select at least one from each of two categories — Thermosetting and Thermoplastics, depending on molding equipment and tooling equipment available)

1. Thermoplastics
   a. Sheet (acrylics, etc., hand forming and shaping)
   b. Thermoforming (blow, vacuum, plug and stretch, etc.)
   c. High and low pressure lamination
   d. Casting (vinyls, etc., rotational and stationary)
   e. Thermofusion (polyethlene pellets, polyethylene powder, polystyrene pellets)
   f. Injection (thermoplastics)
   g. Extrusion (thermoplastics)
   h. Expandable foams (bead and resins)
   i. Others
2. Thermosetting
   a. Resin plastics (polyester and fiber glass)
   b. Casting, potting, and encapsulation
   c. Compression molding
   d. Bonding
   e. Injection and transfer
   f. Expandable foams
3. Combinations of materials
   a. FRP and foams of honeycomb
   b. FRP and plywood or Foam and Plywood
   c. Vacuum or pressure forming and foam

D. Field Trips

E. Films and Film Strips

1. See Units I, II, & III
2. "Plastics: Industrial Processes and Products" F, Society of the Plastics Industry, 250 Park Ave., New York 17, N. Y.
3. "The Manufacture of Plastics" F, SPI, 250 Park Ave., New York 17, N. Y.
4. "Methods of Processing Plastics" F, SPI, 250 Park Ave., New York 17, N. Y.
5. "Plastics Is Your Business" FS, SPI, 250 Park Ave., New York 17, N. Y.
6. "Shaping Tomorrow Today" FS, Owens-Corning Fiberglass Corp., New York 22, N. Y.

F. Texts and References

1. Bick, Alexander, *Plastics: Projects and Procedures W/Polyesters*, Bruce, 1962
2. Cherry, Raymond, *General Plastics, Revised*, McKnight & McKnight, Bloomington, 1964
3. Gerbracht & Robinson, *Understanding America's Industries*, McKnight & McKnight, 1962
4. Hammond, James, *Metal, Woodworking Technology*, McKnight & McKnight, 1961
5. Ludwig, Oswald, *Metalwork, Technology & Practice*, McKnight & McKnight, 1962
6. Modern Plastics Magazine and Encyclopedia
7. SPI, *Plastics Engineering Handbook*, Reinhold, New York 22, N. Y., 1960
8. Steele, Gerald, *Fiber Glass — Projects and Procedures*, McKnight & McKnight, 1962
9. Swanson, Robert, *Plastics*, McKnight & McKnight, 1964
10. Willis, John, *Glass Fiber Auto Body Construction*, Post Pub., Arcadia, Calif.
11. And others

Additional References for All Plastics Units

1. Adams, John, *Plastics Arts & Crafts*, Van Nostrand, New York, 1964
2. Bick, Alexander, *Plastics for Fun*, Bruce, Milwaukee, 1954
3. DeWick, Cooper, *Plastic Craft*, Macmillan Co., New York, 1948
4. Dunham, Arthur, *Working with Plastics*, McGraw-Hill, New York, 1948
5. Groneman, Chris, *Plastics Made Practical*, Bruce, Milwaukee, 1948
6. Mansperger & Pepper, *Plastics Problems & Processes*, International, Scranton, Pa., 1942
7. Newkirk, Hewett & Zutter, *Adventures with Plastics*, New York 17, N. Y.
8. Swanson, Robert, *An Outline for Developing Industrial Arts Plastics*, Stout State College, Menomonie, Wisconsin
9. Edwards, Lauton, *Industrial Arts Plastics*, Chas. A. Bennett Co., Inc., Peoria, Illinois, 1964

As the field grows, curriculums should include

An Introduction to Plastics

By Gerald L. Steele

Industrial-Education Department,
University of Minnesota, Minneapolis

PLASTICS technology, an area of rising importance in industry today, can be, and should be, taught in the school shop. To adequately interpret the role of plastics, industrial-arts students must be acquainted with the materials and processes, thus the intructor needs an understanding of these processes and their many variations.

The following paragraphs will present basic information about materials, equipment, and processes in the form of a general discussion that might be of some help in selecting topics for developing lessons. The injection molding process is discussed in some detail because of its extensive use in industry.

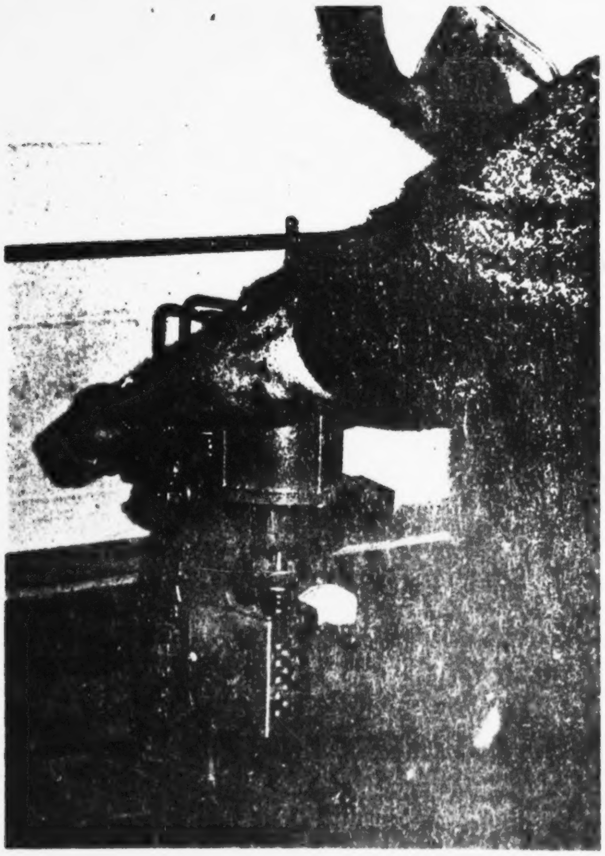
It would be difficult to cite all the many variations of each process, therefore, only the more important basic processes and details will be covered. Details not mentioned are found in the reference materials listing at the end of the article.

Classification of Plastics

Synthetic (man-made) plastics are divided into two general classifications: thermoplastics and thermosetting plastics. These are materials which contain, as an essential ingredient, an organic substance of large molecular weight, are solid in their finished state, and, at some stage in their manufacture or processing into finished articles, can be shaped by flow.

Thermoplastics are those moldable materials which will soften when heated and harden when cooled, similar to candle wax. The material goes through a physical change when heated and cooled.

Thermosetting plastics are those moldable materials which harden when subjected to heat, heat and pressure, or chemicals. Generally, they cannot be remelted or reshaped once they have been cured (polymerized). This process can be compared to an egg which, when boiled, becomes hard and cannot become soft again. This material goes through a definite chemical change when being molded. This change is permanent.



Plastics technology, steadily rising in industrial prominence today, is often neglected in industrial-education programs because of the lack of basic knowledge on the instructor's part. This article is intended as an introduction to materials, equipment, and processes to get a beginning course started. Pictured is a high-school student working with injection-molding equipment.

Plastics Processes

Different molding processes are required for different plastic materials or end products. The choice of process or material is a many-sided decision. No attempt will be made to evaluate those factors. Some of the advantages and disadvantages will be given for the various processes, however. Generally, thermoplastic products are molded by one group of processes and thermosetting plastics by another. Some overlapping of processes does exist, however, but it is not of great importance.

Thermoplastic	Thermosetting
Injection molding	Compression molding
Extrusion molding	Transfer molding
Blow molding	Reinforced molding
Thermoforming	High pressure lamination
Coating and dipping	
Bead foam molding	Resin foam molding
Casting	Casting
Slush molding	Jet Molding
Rotational molding	
Calendering	
Low pressure	
Heat sealing, welding, and cementing	

All the processes can be accomplished economically in the school shop. Equipment for some of the plastics processes is more costly than for others but good long-term planning will result in the purchase of the proper items in the shortest possible time. Processes which

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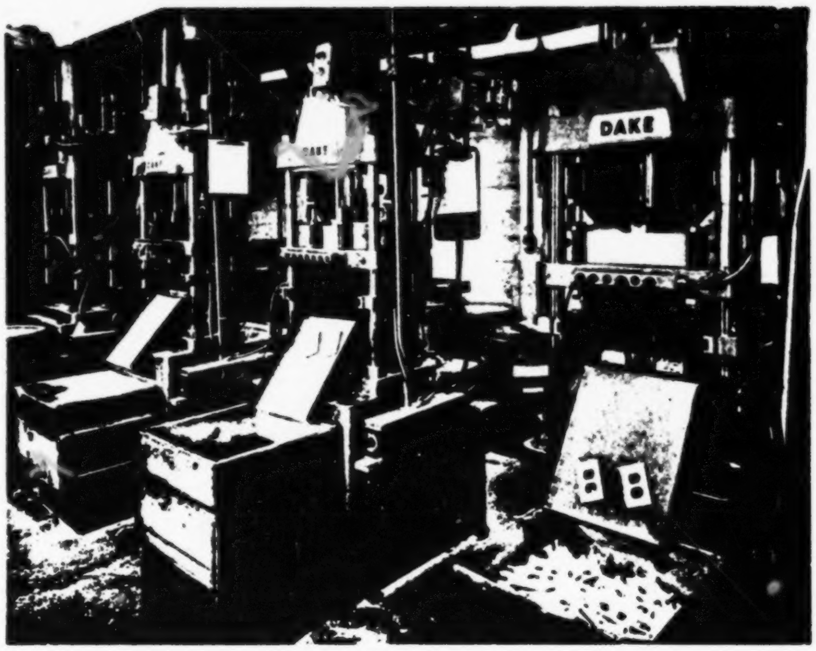
require little or no costly equipment can be implemented as soon as the instructor becomes acquainted with them.

Injection Molding

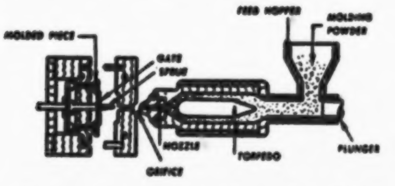
Description of the process.—Injection molding is a process in which a granular thermoplastic molding material is softened (plasticized) by heat and forced (injected) into a closed mold cavity under pressure. It usually requires from 5,000 psi to as high as 40,000 psi to force the material out of the injection ram chamber into the mold cavity. From 25 percent to 75 percent of this ram pressure is actually transferred to the mold, depending on the equipment and mold. Temperatures of from 300°F to 600°F are usually required to plasticize the plastic material to the required flow state prior to entry into the mold. After it is filled the molten plastic is solidified by cooling the mold. The mold is then opened and the part removed.



Here is compression molding being done in industry to produce light-switch plates. A thermosetting process, the author contends, can be taught in the school shop for students to gain a better understanding of the materials and processes through advanced plastics-technology courses.

The injection molding machine is divided into two sections. One section is devoted to the clamping arrangement for the molds. This clamping device is usually hydraulic and holds the molds closed while the material is being injected. It then opens to allow the finished part to be removed. The other section, usually hydraulic also, provides the means of injecting the plasticized plastic material into the closed mold.

Injection molding machines are of two basic types—plunger injection and screw injection. The plunger machine pushes the plastic material forward into the heating chamber by the motion of the plunger, returning to pick up another quantity for the next stroke. The plunger is actuated, in its reciprocal (back and forth) motion, by a hydraulic or air cylinder. The screw injection machine moves the material into the mold by rotation of the screw to plasticize the material and then a reciprocal motion of the screw assembly to force the plastic forward under high pressure and at greater speeds.



Screw type machines have the advantage of heating and mixing plastic materials more thoroughly and rapidly. The material is moved much the same as in a meat grinder. Heating bands surround the chamber in which the screw is located, heating the material as it passes through. The friction generated by the rotation of the screw tends to heat the material too. A torpedo (spreader) is located at the mold end of the chamber to push the material against the walls, further heating, compacting, and plasticizing it.

The forward motion of the screw or plunger forces the plastic through the small opening (nozzle orifice) at the end of the heating chamber and into the mold to form the part.

Industrial applications.—Injection molding is one of the most widely used plastic molding processes and is the most widely used thermoplastic process at present. It is used for long production runs of the low-cost thermoplastic products we use daily. It is readily adaptable to almost all thermoplastic materials, with a wide range of characteristics and properties. Molding cycles are short, often as short as three to 30 seconds, and material costs are low to medium in comparison to thermosetting plastics. Materials cost as little as 15¢ per lb. in large quantity and clean waste material may be reused, reducing the production cost. Some materials cost as much as $2.00 per lb. but most of the production is with the less expensive varieties. Tooling costs are high, as the molds and processing machines are both expensive.

Machine costs range from $300 for a 1/5 oz. school-type molder to about $100,000 for a 200-oz. commercial machine. Recently, machines of capacities as high as 880 oz. have appeared. The machine capacity is figured in the number of ounces, or fraction thereof, of plastic material which the machine can plasticize and inject in one shot.

Mold costs range from about $50 to $30,000 for a single mold, depending on size and complexity.

Common household items like wastebaskets, garbage cans, measuring spoons, toys, tumblers, canisters, and wall tile made from plastic are usually injection molded. An identifying characteristic of injection molded parts is the molding gate projection. This is the place where the plastic material entered the mold cavity. It is most often found on the bottom or side of the part. A round object, such as a food container or tumbler, is a good example. The gate is often found in the center on the bottom as a small tip. This gate is usually not cut off too close, and can be easily found. Side gates are often noticed on other types of parts. They can be found by close examination of the edges of the object.

Industrial-arts application.—Injection molding can be done in industrial arts on any one of several rather inexpensive machines. They range from about $300 to slightly over $1,200. Common industrial plastic molding granules are used in all these machines. Material types run the full range, although some modification of the machines is necessary for hard-to-mold plastics like nylon, vinyls, and Teflon. Special injection molding cylinders and heaters are available for them. Standard equipment cylinders and heaters will handle the common molding materials, such as polystyrene, polyethylene, cellulosics, and others.

Molds can be made with metal-filled epoxies by casting or by machining from aluminum, steel, or brass. The metal lathe and drill press are necessary, while more intricate work can be done with the help of milling, surface grinding, and/or shaping machines.

Metal-filled epoxy molds will stand up on short runs (1,000 to 2,000 parts) and are easy to make. They can be made by casting over a pattern of metal, plastic, wood, or glass. Due to the heat involved in the cure of the epoxy resin, patterns with a low melting point cannot be used. The casting process makes it quite feasible in the school shop, especially where metalworking machines are not available.

Molds cast from high-strength gypsum cement (U.S. Gypsum Ultracal or similar products) look promising for very limited production in the school shop. A retaining flange, all the way around the material and the back side, seems to be necessary. Further investigation of this process is needed. Low-pressure molding materials would probably be used to prevent the mold from cracking. ★

References

Cherry, Raymond. *General Plastics, revised.* Bloomington, Ill.: McKnight and McKnight Publishing Co., 1965.

Modern Plastics Magazine & Encyclopedia. New York.

Plastics Engineering Handbook, third edition. New York: Reinhold Publishing Co., 1960.

Simonds and Church. *Concise Guide to Plastics,* second edition. New York: Reinhold Publishing Co., 1963.

Society of the Plastics Industry. *Injection Molding.* New York, 1965.

——*Plastics: The Story of an Industry.* New York, 1962.

Swanson, Robert. *Industrial Plastics.* Bloomington, Ill.: McKnight and McKnight Publishing Co., 1965.

Films and Filmstrips

"The Loma Story," Loma Industries, 3000 Pafford St., Fort Worth, Tex.

"Automatic Runnerless Injection Molding," Milton Ross Co., 511 Second St., Southampton, Penna.

"Plastics: Industrial Process & Products," The Society of the Plastics Industry, Inc. 250 Park Ave., New York, N. Y. 10017.

"Talking Plastics," SPI.

"The Origin and Synthesis of Plastic Materials," SPI.

Appendix C-6

Basic Reference Library for Plastics*

Bick, A. F. *Plastics: Projects and Procedures with Polyesters.* Bruce Publishing Co., Milwaukee, Wisc., 1962.

Cherry, Raymond, *General Plastics*, Revised 1965, McKnight & Mcknight. Bloomington, Ill., 1965.

Colby, C. B. *Plastic Magic*, Coward McCann, Inc., New York, 1959.

Dearle, Denis A. *Opportunities in Plastics*, Vocational Guidance Manuals, Inc. 800 Second Ave., New York, N.Y., 1963. $2.00.

Edwards, Lauton. *Industrial Arts Plastics*. Chas. A. Bennett Co., Peoria, Ill., 1964. $4.40

Fry, William. *Speaking of Plastics Series*: 1. *Nylon* 2. *Acrylics* 3. *Cellulosics* 4. *Vinyls* 5. *Polystyrene* 6. *Polyethylene* Fry Plastics International, Inc., Los Angeles, Calif., 1963.

Kaminski & Williams, *Welding and Fabricating Thermoplastic Materials*. Kamweld Products Co., Norwood, Mass., 1964. $5.95

Lappin, Alvin. *Plastics Projects and Techniques*. McKnight & McKnight, Bloomington, Ill., 1965. $4.00

Lewis, Alfred. *The New World of Plastics*. Dodd, Mead & Co., New York, 1964. $5.95

Simonds & Church, *Concise Guide to Plastics*. Reinhold Pub. Corp., New York, 2nd Ed., 1963. $12.00

Society of the Plastics Industry, Inc. *Plastics Engineering Handbook*, 3rd edition., Reinhold Pub. Co., 430 Park Ave., N.Y., N.Y. 10022, 1960 $15.00

Steele, Gerald. *Fiber Glass-Projects & Procedures*. McKnight & McKnight, 1962. $4.00

Swanson, Robert. *Plastics Technology*, *Basic Materials & Processes*. McKnight & McKnight, 1965.

Plastics Reference Issue, *Machine Design*. September 17, 1964. Reader Service Dept. Machine Design, Penton Bldg., Cleveland, Ohio, 44113 $2.00

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*Adapted from an *Experimental Resource Unit in Plastics for Industrial Arts* (p. 201).

Appendix D Letters of Evaluation

D-1 John Bichner

D-2 Robert Means

D-3 Claudius Wilken

D-4 Sterling Peterson

Appendix D-1

THE SAINT PAUL PUBLIC SCHOOLS
615 CITY HALL
SAINT PAUL 2, MINNESOTA

February 20, 1967

Mr. Gerald L. Steele, Instructor
Industrial Education
University of Minnesota
Minneapolis, Minnesota 55455

Dear Mr. Steele:

My purpose in writing this letter is twofold.

1. To allow me to express my appreciation for being able to participate in your plastics equipment study, "A Comparison of Plastics Concepts Learned Using Educational Toys and Three Dimensional Models and Concepts Learned Using Commercial Plastics Processing Equipment." I have enjoyed participating in this study and feel that I have gained a great deal in both information and experience.

2. To give you an evaluation of equipment and the course of study. I will also include student reaction to the equipment and the course in general.

Evaluation of equipment used and student reaction to the equipment.

Compression Mold -- mock-up.

The mock-up was well constructed and showed the process of compression molding, but it lacked reality in that no material was used and no product resulted. I had the students make a drawing of the mock-up and explain the process. Many good drawings were turned in and explanations were good, but there was a lack of interest in the model itself.

Heat Sealers and Plastic Welder Mock-ups.

These mock-ups also were well constructed and looked like the actual plastics equipment. But, again, the boys could not use the equipment in an actual plastics application and therefore seemed disinterested in the process. Here, too, I had the students draw and explain the processes. The drawings were good and the explanations were fair, but the interest was poor.

Injection Molding Toy -- Kenner's.

The machine was slow to heat up and required a long time to melt plastic even when hot. Molds often did not fill completely and were difficult to take apart. The plastic material itself seemed of poor quality and broke easily. The students were anxious to use the machines, but only the better students obtained good results.

The poorer students had little success in completing a project and often gave up after several attempts. Approximately 15-20 students completed a project on it.

Vacuum Forming Toy -- Mattel.

This machine was well constructed and heated up quickly. There was little waste of materials. I feel that it did a good job of showing the concepts involved in vacuum forming and would be good introductory equipment when followed by a commercial vacuum former. My students enjoyed using the machines and many good projects resulted. All students completed at least one project, while some completed more.

Compression Molder -- Carver Hydraulic press, 12 ton.

I feel that this machine did an excellent job of showing the compression molding process. The boys were able to start with a thermosetting powder, heat and compress the powder, watch the waste plastic flow from the mold, and end up with a cured part in a time period of about three minutes. The boys enjoyed using the press and all completed at least one coaster for a glass.

Injection Molder -- Siplomatic.

The injection molder was simple to operate and very popular with the students. Being air operated it seemed like an actual industrial machine. The only problem that was involved in this operation was that the molds would heat up and the molding would have to stop until the mold cooled off. In a way the heating of the mold was good because I had the boys use the SPI Booklet on Injection Molding and critized their parts. If the part was warped or dented they would explain that the mold or material was too hot, or if the part was not filled out they would say they had a short shot or the material was cold and would not flow. The part being made was a bottle cap. All students used the machine, and it was a rare case if the person didn't complete several caps.

Plastic Welder -- Seelye.

Each student was given enough material to complete two welds. All students completed their welds, but only the average and better students succeeded in getting good welds. It was an interesting experience for the boys. The welder was treated with respect because of the hot barrel and air. One problem encountered was starting and stopping the operation. Once the students shut off the air supply before the electricity causing overheating. The welder was quite a durable tool.

Heat Sealing Iron -- Roller Knife.

The plastic material that we used with these machines was not the exact type that was needed. The boys were able to cut plastic sheet and rope and they were also able to weld the rope back together. But inform results were not achieved in sealing the sheet plastic and a project such as a comb case could not be completed with any degree of success.

Vacuum Forming Press -- Di-Arco.

This was the largest plastic machine that was involved in the study, and also one of the more difficult to operate. Each student was given two pieces of plastic and he had his choice of three molds to use in the press. The time cycle for completing a part was longest on this machine. Most of the students, but not all, succeeded in making one good part.

Evaluation of course materials.

In my opinion the choice of movies and filmstrips was excellent. For example, when I lectured on types of plastic materials I was able to use the SPI filmstrip and this showed the actual plastic materials and products. The same was true of the other filmstrip and films that were used. The class text and supplementary SPI booklets were also excellent. The boys had to refer to these materials many times for drawings, explanations of processes, or when molding, to critize their work. There were little or no objections when using these materials because the material was interesting, well written, and well diagramed. I was exposed to a large area of reference materials that I did not know existed, and I am still sending for more materials. I still subscribe to Modern Plastics magazine. I feel this is one of the best ways of keeping up with changes in the plastics industry.

Comments on the course

I liked the way the course was organized, and I felt that the content was thoroughly planned. In other words, I was comfortable in teaching the course with the outline and materials that I had available. Because of the organization of the materials, I was able to follow the time schedule very closely.

The supplementary materials such as textbooks, booklets, films, filmstrips, and transparencies were excellent.

Although I did not treat them as such, when working with the toys and mock-ups, the boys treated them as toys. They enjoyed using them, but did not think in terms of the plastics process. Rather they were making a toy with a toy machine, and the process was of little concern. When working with the machines there was respect for the process and the language or terminology of the industry was used. Examples: cure time, slash, short shot, and many other words.

I feel that the students enjoyed bothttreatments. They were learning something new that was presented in an interesting manner. Most students at the end of the course were able to identify many of the common plastics either through their use or appearance. I also feel that all students had a good understanding of the basic plastic process when they finished the course.

The test covered the material included in the course very well. It was easy to administer and take. The vocabulary used seemed appropriate for this grade level.

It is my feeling that in my years of teaching industrial arts this is as close as I have come to teaching about industry in any of my classes.

Again, I want to thank you for being allowed to work in your study.

Sincerely,

John P. Bichner

John F. Bichner, Instructor
Industrial Arts
Como Park Junior High School

Appendix D-2

Minneapolis Public Schools
ANTHONY JUNIOR HIGH SCHOOL
5757 Irving Avenue South   Minneapolis, Minnesota 55419

William C. Cooksey, *Principal*

February 23, 1967

Mr. Gerald L. Steele, Instructor
Industrial Education
University of Minnesota
Minneapolis, Minnesota 55414

Dear Mr. Steele:

I wish to take this opportunity to express my appreciation to you for the chance to participate in your study, "Comparison of Plastic Concepts Learned Using Educational Toys and Three Dimensional Model and Concepts Learned Using Commercial Plastic Processing Equipment". While furnishing you with the desired data it has provided me with a wealth of basic fundamental information for my future classes in General Plastics. I wish to convey to you the reactions of the students and myself as to the practicality of the models, mock-ups, toys and plastic equipment used in your study.

MODELS AND MOCK-UPS

Compression molder - This model was very well designed and an excellent job of showing the parts and how a compression molder works. It would be especially useful in teaching the principles of compression molding in the classroom.

Hot gas welder - This model conveyed the idea of what a welder looked like. Being a model it didn't give the student a chance to weld or see the actual results of welding.

Heat sealer - This model resembled very much the actual heat sealer. Again the student could see a replica of the actual equipment, but could not get the feel of actually performing the task.

TOYS

Mattel Vac-U-Maker - This toy did an excellent job of teaching the principles of vacuum forming. I felt that this toy would be a good addition to a plastic shop because it is inexpensive, easy to operate, and the materials are low in cost. This toy, along with a commercial vacuum forming machine, would give the students a complete understanding of vacuum forming. The students seemed to like to operate this machine and most of the results were very good.

Kenner's Electric Mold Master - This toy injection molder proved to be a very inadequate piece of shop equipment. It had an extremely long cycle time and the results in most cases were very poor.

COMMERCIAL PLASTIC EQUIPMENT

Dake Compression Molder - This machine gave the students a chance to work with compression molding materials, mold, and perform the compression molding process. The Dake molder could do everything the compression molding mock-up could do plus the actual molding. I felt that each student had a better understanding of compression molding by actually getting a chance to make one object on this machine. We still need a much greater variety of molds.

Unex Jet Injection Molder - This was a very popular machine with all the students. I had to limit the amount of raw plastic that was given to each student to control the operating time. It was a challenge for the students to see who could end up with the greatest number of acceptable golf tees.

Hot Gas Welder - Our shop time wasn't long enough for many students to get a chance to weld. I did, however, urge those students who didn't get a chance to perform this operation to at least observe one of his fellow students weld.

Heat Sealing Iron - I am sure each student would agree that this tool did an excellent job. It was easy to use and produced uniform results.

I would like to make the following comments regarding the plastic course for your study:

1. I felt that the course content was very thoroughly planned and organized.
2. It gave the student a good idea of our plastic industry.
3. It made it possible for the students to be able to recognize and identify most common plastics.
4. The student had a comprehensive knowledge of many plastic processes.
5. The students in my class were very enthusiastic about this course from the start to finish. In fact, some of the students who were not involved in the project felt rather left out and disappointed.

The test, I felt, was well planned, very complete, and measured all the informational units. I liked the way the test measured the students ability to apply his general knowledge of plastics to a given situation. The time allotted for the test seemed adequate.

The choice of movies and film strips for this project were very good. The movies and film strips were especially helpful in giving the student a better insight into the plastic industry. It also gave the students a chance to see the difference between our models, toys, industrial arts machines and the machines used in industry.

Thank you again for all the help you have given me.

Sincerely yours,

Robert B. Means

Robert B. Means

RBM/ecm

Minneapolis Public Schools
SPECIAL SCHOOL DISTRICT NO. 1
SCHOOL ADMINISTRATION BUILDING
807 Northeast Broadway Minneapolis, Minnesota 55413

STERLING D. PETERSON
Consultant in Industrial Arts

January 27th, 1967

Mr. Gerald Steele
227 Burton Hall
University of Minnesota
Minneapolis, Minnesota 55455

Dear Jerry:

I wish to thank you on behalf of the industrial arts teachers in Minneapolis for conducting a pilot program in plastics technology at Anthony Junior High School. The instructor and the students of this school were very thrilled with the program which has created much interest in the plastics industry.

This pilot program was explained to industrial arts teachers throughout the city at a departmental meeting last fall. The teachers were very enthusiastic about the program and many are presently in the process of up-dating themselves in this area so that they may be qualified to teach plastics technology. As schools are rehabilitated, compression, injection and vacuum-forming equipment is installed in the rehabilitated shop.

I think you can see from the above statements that your pilot program has created a great deal of interest and has been instrumental in starting new programs in this area of industry.

Yours truly,

Sterling Peterson

Sterling D. Peterson,
Consultant in Industrial Arts

SDP:mm

Appendix D-4

INDEPENDENT SCHOOL DISTRICT NO. 625
THE SAINT PAUL PUBLIC SCHOOLS
615 CITY HALL
SAINT PAUL, MINNESOTA 55102

January 27, 1967

SUPERVISOR'S OFFICE
716 CITY HALL

Mr. Gerald Steele
University of Minnesota
227 Burton Hall
Minneapolis, Minnesota 55455

Dear Mr. Steele:

I apologize for the tardiness of this letter, but there are good reasons.

I wish to thank you for selecting our Como Park Junior High School for your experimental pilot program in plastics. It was a privilege and an educational experience for our teachers and me to work with you. There has been an increase in interest among our industrial arts teachers in offering our youth an experience in the plastic industry. Several areas wish to incorporate plastics as a unit, however, the woodshop area will have it. We had some plastics before, but your pilot stimulated interest and stepped up the process of change.

Thank you again. If there are other areas of cooperation with the University of Minnesota, we in St. Paul stand ready.

Sincerely,

Claudius W. Wilken,
Supervisor Industrial Arts

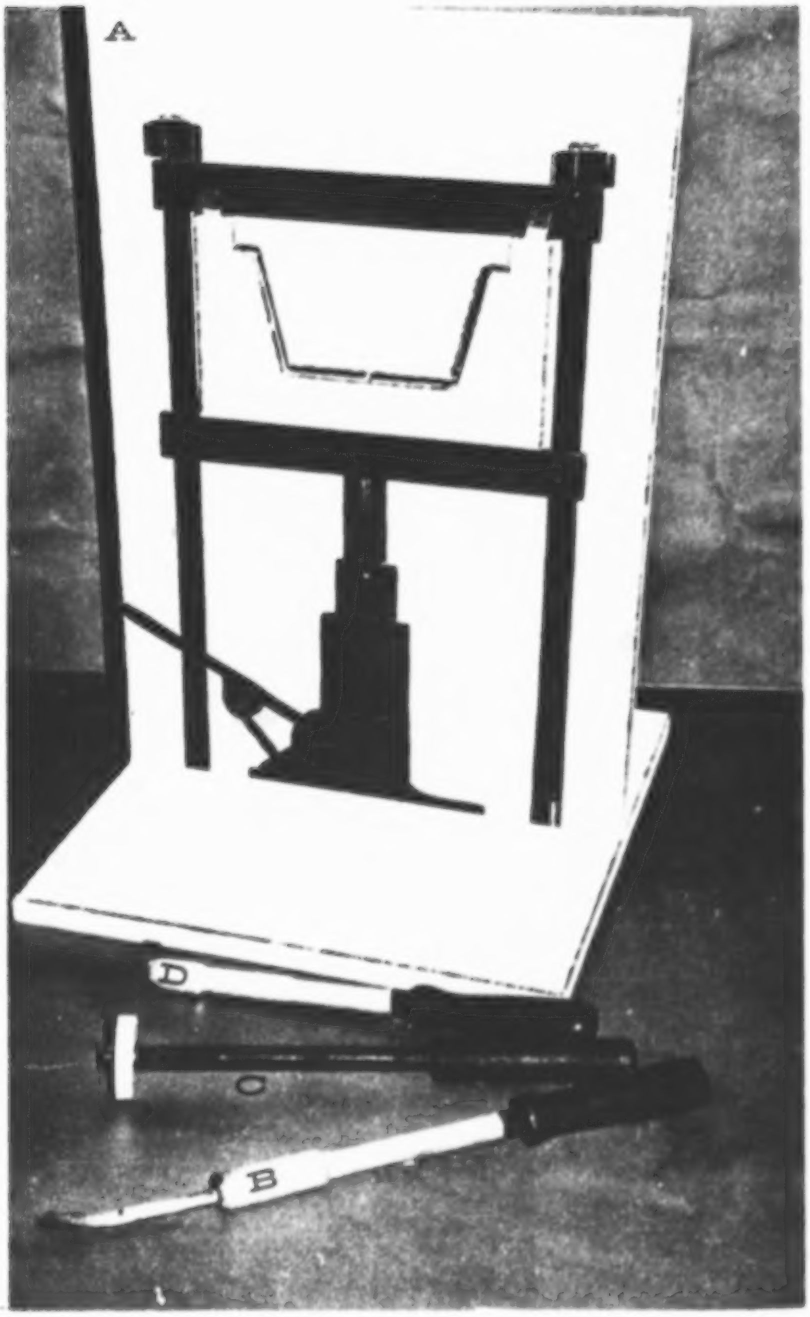
CWW/fp

Appendix E Photos of Equipment

E-1 Mock-ups

Appendix E-1

MOCK - UPS



A - Compression Molder Mock-up
B - Plastics Welder Mock-up
C - Heat Sealer Mock-up
D - Heat Sealer Mock-up